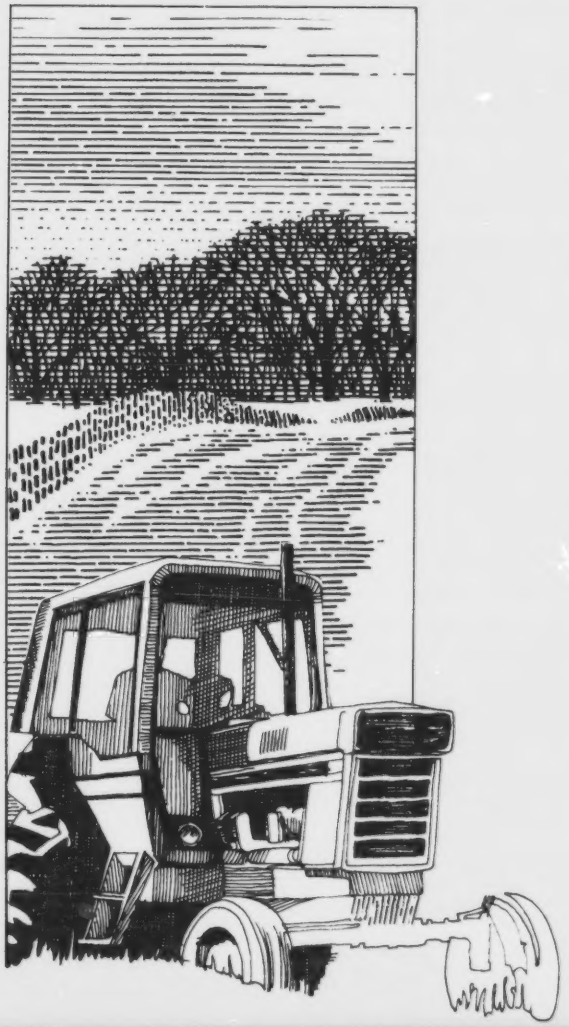
Manitoba
Agriculture

FIELD CROP
PRODUCTION GUIDE FOR MANITOBA 1988-90



THIS 3-YEAR PUBLICATION SHOULD BE USED IN CONJUNCTION WITH THE ANNUAL BOOKLET FIELD CROP VARIETY RECOMMENDATIONS FOR MANITOBA

FIELD CROP PRODUCTION GUIDE FOR MANITOBA 1988-90

Prepared by

Manitoba Agriculture in cooperation
with Agricultural Research Personnel in Industry,
the University of Manitoba and Agriculture Canada.

This publication is designed to provide up-to-date production recommendations for growing field crops. Additional information is available in printed form from Manitoba Agriculture. Contact your local Agricultural Representative office, or write to:

MANITOBA AGRICULTURE
Publications Distribution
411 York Avenue
Winnipeg, Manitoba, R3C 3M1
Telephone: (204) 945-3846

Ask for the *List of Publications* and information on a specific crop.

CONTENTS

Introduction

Use of Good Seed 6
Crop Production 6
Optimum Crop Management (OCM) 6
Disease Control 7
Inoculation of Pulse Crops 17
Weed Control 18
Herbicide Residues 19
Insect Pests 19

Fertilizer Use

Soil Testing 21
Major Nutrients for Annual Crop Production 22
Micro-Nutrients 26
Plant Tissue Analysis 26
Organic Soils 26
Erosion Control 29
Minimum Tillage 31
Zero Tillage 31

Grain Drying and Storage of Damp Grain

Aeration 32
Heated-Air Grain Dryers 34
Storage Moulds 36
Prevention and Control of Insects and Mites in Farm Stored Grain 36

Cereal Crops

Barley 38
Oats 40
Rye 41
Triticale 43
Wheat 44
Winter Wheat 47

Oilseed and Special Crops

Buckwheat 50
Canaryseed 51
Canola/Rapeseed 52
Fababeans 54
Field Beans 56
Field Peas 58
Flax 59
Lentils 61
Mustard 62
Potatoes 64
Safflower 66

Soybeans 66
Sugar Beets 67
Sunflowers 69
Wild Rice 72
Corn 73

Forage Crops

Seeding Practices 84
General Management of Grass and Legumes 87
Making Good Quality Hay and Silage 91
Pastures and Pasture Management 94

TABLES

Table 1 Crop-Disease Relationships 11
Table 2 Seed Treatment — Fungicides and Insecticides 12
Table 3 Foliar Applied Fungicides 16
Table 4 Insect Pests 20
Table 5 Common Fertilizers 29
Table 6 Crop Residue Requirements for Wind Erosion Control 30
Table 7 Slope and Recommended Quantity of Residue 30
Table 8 Effect of Several Types of Tillage Implements on Residue Cover 31
Table 9 Summary of Basic Recommendations for Drying and Cooling Processes 33
Table 10 Maximum Storage Moisture Contents 36
Table 11 Maximum Drying Temperatures 36
Table 12 Barley — General Rate of Nutrient 39
Table 13 Oats — General Rate of Nutrient 41
Table 14 Rye — General Rate of Nutrient 42
Table 15 Triticale — General Rate of Nutrient 44
Table 16 Wheat — General Rate of Nutrient 45
Table 17 Wheat — Nitrogen Fertilizer Requirements 46
Table 18 Winter Wheat — General Rate of Nutrient 49
Table 19 Buckwheat — General Rate of Nutrient 50
Table 20 Canola/Rapeseed — General Rate of Nutrient 52
Table 21 Flax — General Rate of Nutrient 60
Table 22 Mustard — General Rate of Nutrient 62
Table 23 Potatoes — General Rate of Nutrient 64
Table 24 Sugar Beets — General Rate of Nutrient 68
Table 25 Sunflower Seed and Row Spacing 69
Table 26 Sunflower Seed Size and Weight 70
Table 27 Sunflowers — General Rate of Nutrient 71
Table 28 Corn — Seed Spacing Necessary for Required Plant Population 76
Table 29 Corn — General Rate of Nutrient 77
Table 30 Grass Adaptation Guide 103
Table 31 Legume Adaptation Guide 105
Table 32 Recommended Grasses 81

Table 33 Recommended Legumes 81
Table 34 Recommended Mixtures 82
Table 35 Forages — Planting Guide 83
Table 36 Grasses — Annual General Rate of Nutrient 88
Table 37 Grasses — Annual Time of Fertilizer Application 89
Table 38 Legumes — Annual General Rate of Nutrient 89
Table 39 Hay and Silage — Dry Matter Losses (Percent) 92
Table 40 Types of Storage and Recommended Forage Moisture Content 93
Table 41 Recommended Harvesting Moisture Contents 94

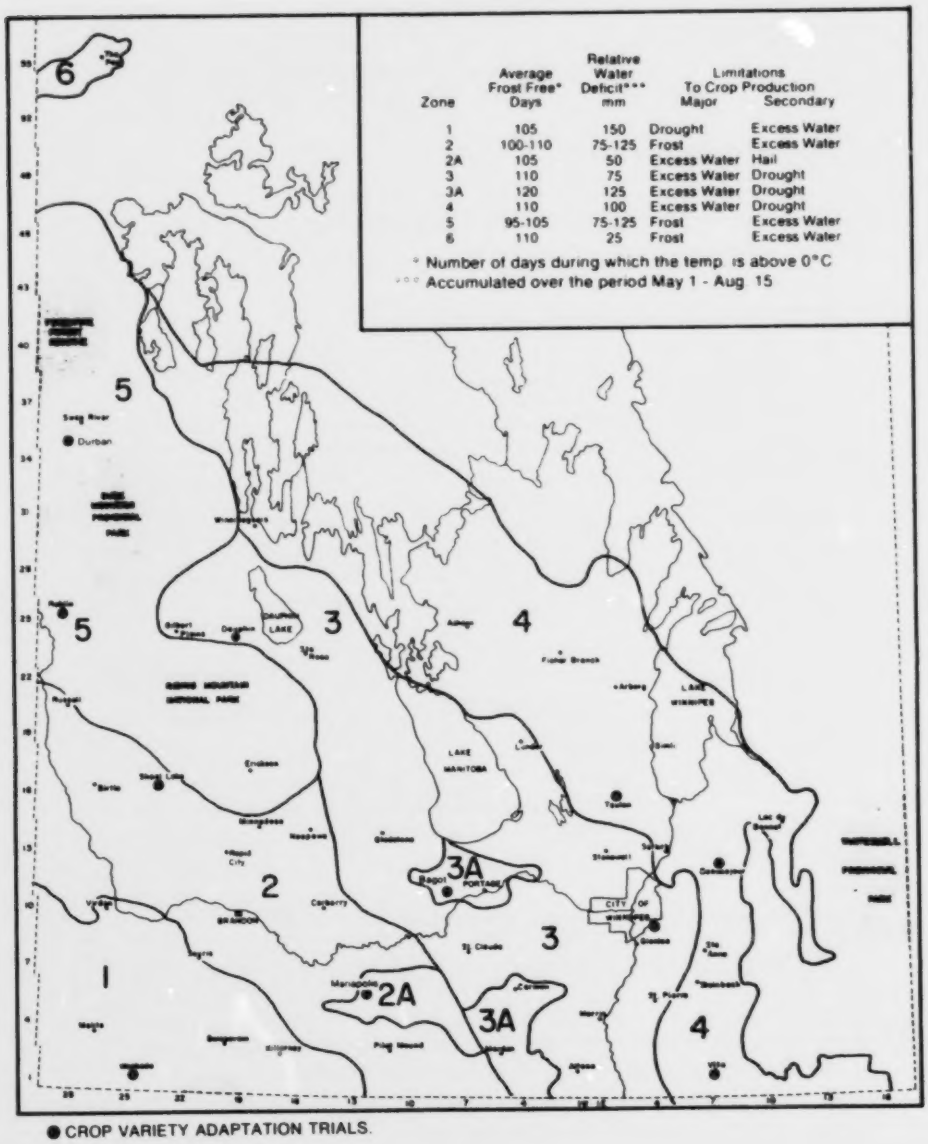
FIGURES

Figure 1 Crop Variety Zone Map for Manitoba 5
Figure 2 Moisture Migration in Stored Grain — Fall and Winter ... 33
Figure 3 Fungus Feeding Pests 37
Figure 4 Corn Heat Unit Map for Manitoba 73
Figure 5 Minimum Accumulation of Corn Heat Units at a 25% Risk 74
Figure 6 Minimum Accumulation of Corn Heat Units at a 10% Risk 75
Figure 7 Grain Corn Insurance Areas 79
Figure 8 Silage Corn Insurance Areas 80
Figure 9 Sample of Certified Seed Tag 84
Figure 10 Relative Yield and Period of Growth of Native Grass and Seeded Pastures 95

PHOTOS

Photo 1: Barley — Yellow Dwarf 8
Photo 2: Wheat — Leaf Rust 8
Photo 3: Wheat — Septoria Leaf Blotch 8
Photo 4: Barley — Loose and Covered Smut 8
Photo 5: Canola/Rapeseed — Blackleg 9
Photo 6: Canola/Rapeseed — Stem rot showing Sclerotia inside of stem 9
Photo 7: Field Peas — Blight 9
Photo 8: Potatoes — Early Blight 9

Figure 1 — CROP VARIETY ZONE MAP FOR MANITOBA



Zone	Average Frost Free* Days	Relative Water Deficit*** mm	Limitations To Crop Production Major	Secondary
1	105	150	Drought	Excess Water
2	100-110	75-125	Frost	Excess Water
2A	105	50	Excess Water	Hail
3	110	75	Excess Water	Drought
3A	120	125	Excess Water	Drought
4	110	100	Excess Water	Drought
5	95-105	75-125	Frost	Excess Water
6	110	25	Frost	Excess Water

* Number of days during which the temp. is above 0°C

*** Accumulated over the period May 1 - Aug. 15

● CROP VARIETY ADAPTATION TRIALS.

INTRODUCTION

Use of Good Seed

Always use good, preferably pedigreed seed of a recommended variety. Pedigreed seed consistently outyields poorly cleaned seed. Thorough cleaning removes weed seeds and most diseased kernels and retains only the large kernels which produce larger, more vigorous plants.

Crop Production

Successful crop production depends on a number of inter-related factors. This must be kept in mind when making decisions on production inputs. Factors to be considered include:

- seedbed type and preparation
- seed variety and quality
- seed treatment
- seeding methodology and timing
- fertilizer application
- pest control including weeds, insects and plant diseases
- harvesting methods.

In general, optimum results are obtained when the proper balance of inputs is tailored to the particular soil and climatic conditions involved. For example, maximum returns from good quality seed and fertilizer are only achieved when accompanied by other management factors such as timelineness and good pest control. In addition, the level of inputs required will depend upon the particular soil and climatic factors involved, such as moisture holding capacity of the soil or rainfall and frost free periods.

Deciding which crop to grow involves both the cultural practices of each crop and the economic factors.

To assist farmers in making these decisions, Manitoba Agriculture has developed a Crop Planning Guide, which estimates costs and returns for various crops. The Crop Planning Guide is available at your local Ag Rep office.

Optimum Crop Management (OCM)

OCM is the production of a crop where each management input is applied at the optimum rate and time. OCM begins with seedbed preparation, seed selection, seed treatment, seeding rate and methodology, fertilizer application, and weed, insect and disease control. It may also include the use of plant growth regulators (PGR's) to control lodging.

Experience in Europe has indicated that as crop production is intensified by the use of higher plant populations and fertilizer, higher levels of disease control and lodging resistance are required. In Manitoba, fungicides

have not been adequately evaluated except for winter wheat and certain special crops such as canola (rapeseed) and potatoes which are very susceptible to disease. Although research has been conducted on the use of PGR's on some cultivars of barley and wheat, more work is required before specific recommendations on rates and stages of application for the different cultivars are available for Manitoba.

Seed Treatment

Chemical seed treatments can be used to control diseases such as smuts which attack wheat, barley, oats and rye, and seedling diseases that infect canola, rapeseed and mustard.

Disease Control

When smut is observed in a crop being used for seed, it should be treated. If producers use their own seed of a susceptible variety and there is doubt as to infection by smut or bunt, seed treatment is a wise precaution. The recommended interval between treatments is given for the various crops in the Manitoba Agriculture Factsheets 'Diseases Affecting Wheat', 'Diseases Affecting Barley', and 'Diseases Affecting Oats'. These publications will also assist producers in identifying smut.

Use a suitable chemical with a Pest Control Products Act number (PCP No.). Recommended chemicals are shown in Table 2. Seed treatment chemicals are poisonous so guard against inhaling dust or fumes, and wear a mask when recommended on the product label. Wash with soap and water periodically to remove chemical lodged on hands and face while treating.

Thoroughly clean equipment used in moving treated grain before it is used for untreated grain. Empty chemical containers should be taken to a Pesticide Container Disposal site.

CAUTION: Treated grain must not be mixed with untreated grain for feed or sale. Treated leftover seed may be saved for planting the following year; otherwise it should be buried at a depth and location where it will not be accessible to animals or contaminate water supplies.

Sclerotinia Diseases *Sclerotinia sclerotiorum* can cause serious disease in a great variety of broadleaved field crops including fababeans, field beans, field peas, lentils, mustard, canola, rapeseed, safflower, soybeans and sunflower. Vegetable crops such as green beans and garden peas, along with many weeds such as thistles, wild mustard, ragweed, and burdock are hosts.

It overwinters in Manitoba soils by means of black, hard bodies or sclerotia, variable in shape (round, flat, short, elongated) and size (measuring from a few millimetres to several centimetres). Infection is caused in two ways:

- by direct germination
- by airborne spores.

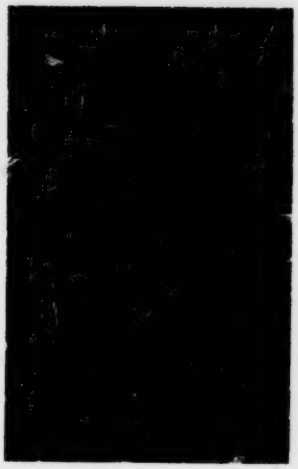


Photo 1
Barley — Yellow Dwarf

Photo 2
Wheat — Leaf Rust

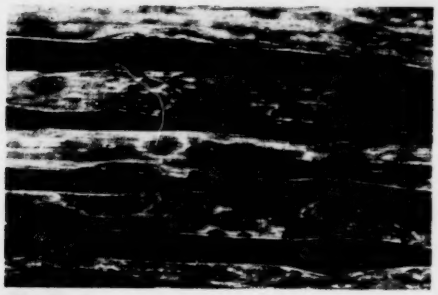


Photo 3
Wheat — Septoria Leaf Blotch

Photo 4
Barley — Loose and Covered Smut

Photo 5
Canola/Rapeseed — Blackleg

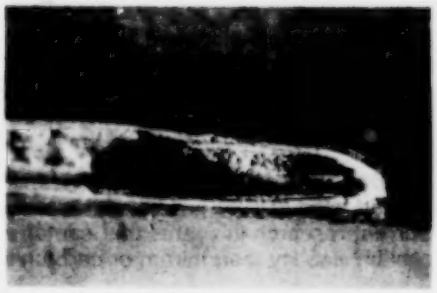


Photo 6
Canola/Rapeseed — Stem Rot Showing Sclerotia Inside of Stem

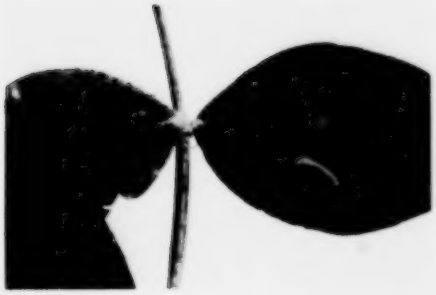


Photo 7
Field Peas — Blight

Photo 8
Potatoes — Early Blight

Direct germination causes root infection and occurs primarily in sunflowers. This infection results in root rot and basal stem rot, noticeable by a wet lesion at the stem base and a sudden wilting of the plant. Infection by ascospores causes head and stalk rot in sunflower, and white mold or stem rot in other crops. Spore infection occurs under conditions of continuous heavy rainfall.

Airborne infections are further enhanced by the presence of senescent (old or dead) tissue such as florets of sunflower heads and flower petals of other crops that drop and become lodged in leaf axils. Senescent tissue is needed — by the germinating spore as a food base, in order for the infection to be successful.

Sclerotinia diseases are partially controlled by at least a four year rotation between host crops, as well as use of sclerotia-free seed and weed control. Airborne infections are further reduced by seeding to allow maximum air circulation and fast drying, and by timely spraying with recommended chemicals on approved crops. With sunflowers, damage from Sclerotinia Wilt is reduced by using minimum populations planted at maximum distances (refer to Sunflower section — Seeding).

***Rhizobium* — Fungicide Toxicity** The viability of Rhizobium inoculum applied to pulse crop seeds may be reduced by fungicide seed treatment. Current research indicates that captan may be more detrimental to Rhizobium viability than thiram or carbathiin.

TABLE 1: CROP — DISEASE RELATIONSHIPS

For Crop Rotation Consideration / DISEASES	CROP																					
	ALFALFA	BARLEY	BUCKWHEAT	CORN	FABABEANS	FIELD BEANS	FIELD PEAS	FLAX	LENTILS	MUSTARD	OATS	POTATOES	RAPESEED	RYE	TRITICALE	SAFFLOWER	SOYBEANS	SUGAR BEETS	SUNFLOWERS	SWEET CLOVER	WHEAT	LONGEVITY *
Ascochyta Blight					A		B		C													4
Alternaria-Grey Leaf Spot										X			X									1
Bacterial Blight						A	B										C					1
Cyst Nematode										X			X					X				3
Ergot		X												X	X						X	1
Fusarium Wilt & Root Rot	X				X	X	X	X	X	X			X				X		X	X		S
Fusarium Head Blight (Scab)		X		X																	X	1
Helminthosporium — Common Root Rot		X																			X	2
Rhizoctonia Root Rot	X		X		X	X	X	X	X	X		X	X				X	X	X	X			S
Sclerotinia	X				X	X	X		X	X		X	X			X	X		X	X		4
Septoria (Cereals)		A									B										C	1
Verticillium Wilt	X											X							X	X		4
White Rust — Staghead										A			B									3

Diseases with different letters have same name on various crops but are caused by different species or biotypes of the pathogen. This implies that there is little risk of this disease spreading between the indicated crops.

* = longevity of pathogen in soil or on trash in years.

S = pathogen is a soil organism and can survive indefinitely.

X = disease can occur on crop.

TABLE 2: SEED TREATMENT — FUNGICIDES AND INSECTICIDES

ACTIVE INGREDIENTS	INSECT: WIREWORMS: Wheat	Oats	Barley	Rye	Flax	SEED MAGGOTS: Field Beans	Corn	Soybeans	FLEA BEETLES: Canola (Rapeseed)	Mustard	DISEASE: SEED AND SEEDLING ROTS/BLIGHTS: Canola (Rapeseed)	Mustard	Peas	Cereals	Flax	Rye	Corn	Field Beans	Soybeans	SMUTS CARRIED ON SEED: Corn-Head Smut	Rye-Stem Smut	Wheat-Bunt	Oats-Smut	Barley-Covered	Barley-False Loose	SMUTS CARRIED IN SEED: Whea'-Loose Smut	Barley-Loose Smut	BLACK LEG: Canola (Rapeseed)	Verticillium Wilt: Alfalfa
INSECTICIDES																														
carbofuran (Gr)									●	●																				
lindane (Wp)	●	●	●	●		●	●																							
terbufos (Gr)									●	●																				
FUNGICIDES																														
benomyl-thiram (Du)											●																		●	
captan (Du, Wp)													●				●	●	●											
carbathiin (Sn)															●	●					●	●	●	●	●	●	●	●		
carbathiin-thiram (Du)														●	●	●			●		●	●	●	●	●	●	●	●		
carbathiin-thiram (Su)														●	●	●	●		●	●	●	●	●	●	●	●	●	●		
fenaminosulf (Wp)													●																	
maneb (Du, Su)														●	●	●							●	●	●	●				
mancozeb (Wp)															●								●	●	●	●				
thiram (Su, Wp)											●	●	●				●	●	●											●

(Continued on page 13)

TABLE 2: SEED TREATMENT — FUNGICIDES AND INSECTICIDES (CONT.)

ACTIVE INGREDIENTS	INSECT: WIREWORMS: Wheat	Oats	Barley	Rye	Flax	SEED MAGGOTS: Field Beans	Corn	Soybeans	FLEA BEETLES: Canola (Rapeseed)	Mustard	DISEASE: SEED AND SEEDLING ROTS/BLIGHTS: Canola (Rapeseed)	Mustard	Peas	Cereals	Flax	Rye	Corn	Field Beans	Soybeans	SMUTS CARRIED ON SEED: Corn-Head Smut	Rye-Stem Smut	Wheat-Bunt	Oats-Smut	Barley-Covered	Barley-False Loose	SMUTS CARRIED IN SEED: Wheat-Loose Smut	Barley-Loose Smut	BLACK LEG: Canola (Rapeseed)	Verticillium Wilt: Alfalfa
DUAL PURPOSE																														
benomyl-captan lindane (Du, Su)									●	●	●	●																	●	
iprodione-lindane (Su)									●																				●	
benomyl-thiram lindane (Du)									●		●																		●	
captan, diazinon (Wp)						●	●	●					●				●	●	●											
captan, thiophanate-methyl, diazinon (Du)																		●												
captan-lindane-diazinon (Du)						●	●	●					●				●	●	●											
carbathiin-lindane (Sn)	●	●	●											●								●	●	●	●	●	●			
carbathiin-thiram- (Du)	●	●	●	●	●									●	●	●					●	●	●	●	●	●	●			
lindane (Su)	●		●						●	●	●	●		●								●		●	●	●	●	●		
maneb-lindane (Du)	●	●	●	●										●								●	●	●	●					

Du — Dust
Wp — Wettable Powder
Su — Suspension
Sn — Solution
Gr — Granules

INDEX TO TABLE 2 — SEED TREATMENTS

CHEMICAL	FORMULATION	PRODUCT NAME
Benomyl, captan, lindane	Su, Du	Gammasam plus Flowable Rapeseed Treatment
	Du	Gammasan Seed Treatment Powder
Benomyl, thiram	Wp	Benlate T Benomyl — Thiram Fungicide Seed Dressing
Benomyl, thiram,	Du	Thiralin-Plus
lindane	Du	Ipco Benolin-R Insecticide/ Fungicide Dust
Captan	Su	Chipman Flowable Seed Treatment
	Wp	Captan 76 Seed Protectant
	Su	Captan SP-4 flowable
Captan, diazinon	Wp	Chipman Agrox I.F. Dual Purpose Seed Treatment
Captan, lindane, diazinon	Du	Agrox D-L Plus Insecticide/ Fungicide Drill and Seed Treatment Powder
	Du	Pickseed DLC Seed Box Treatment
	Du	Drillbox Diazinon-Lindane Plus captan Seed Treatment Powder
	Du	Ciba-Geigy DCL Slurry Dual Purpose Seed Treatment
	Du	Pfizer - DCL Drill Box Seed Treatment
	Du	Co-op Rapeseed and Mustard Seed Treatment
	Du	Co-op D-L & C Drill Box Seed Treatment
	Wp	Chipman B-3 Dual Purpose Seed Treatment
Captan, thiophanate -methyl, diazinon	Du	DCT Dual Purpose Seed Treatment
Carbathiin	Sn	Vitaflo 250
	Sn	Vitavax Single Solution
	Sn	Vitavax Solution Seed Protectant
Carbathiin, lindane	Sn	Vitavax Dual Solution
Carbathiin, thiram	Du	Vitavax Powder
	Su	Vitaflo 280, Anchor
Carbathiin, thiram,	Du	Vitavax RS Powder
lindane	Su	Vitavax RS Flowable
	Du	Vitavax Dual Powder Seed Protectant
	Su	Vitaflo DP
Carbofuran	Gr	Furadan CR-10
	Gr	Furadan 5G
Fenaminosulf	Wp	Lesan
Iprodione, lindane	Sn	Rovral ST
Lindane	Wp	Lindane
Maneb	Wp	Agrox NM Drill Box & Slurry Seed Treatment Powder
	Su	Agrox Flowable Seed Treatment Fungicide

(Continued on page 15)

INDEX TO TABLE 2 — SEED TREATMENTS (CONT.)

CHEMICAL	FORMULATION	PRODUCT NAME
	Du	Pool NM Drill Box Seed Treatment
	Du	Pool Seed Treat Powder
	Wp	Manzate D. Agro. Fung.
	Du	Co-op NM Drill Box Seed Treatment
Maneb, lindane	Du	Pool NM Dual Purpose Drill Box Seed Treatment
	Su	Mergamma Flowable Dual Purpose Seed Treatment
	Du	Pool Dual Purpose Seed Treatment
	Du	Mergamma NM Drill Box Dual Purpose Seed Treatment
	Du	Co-op NM Dual Purpose Seed Treatment
Mancozeb	Wp	Dithane M-45 Seed Protectant
	Wp	Manzate 200 Mancozeb Fungicide
Metiram	Wp	Polyram 7 Dust
	Su	Polyram 7 Fungicide Seed Protectant
Terbufos	Gr	Counter 5G
Thiram	Su	Gustafson 42-S Thiram Fungicide
	Wp	Thiram 76 WP Wettable Powder Fungicide
	Su	Thiram 320 Flowable Fungicide
	Wp	Thiram 75-Wp
	Wp	Pfizer Thiram 75 Seed Fungicide Du

INDEX TO TABLE 3 — FOLIAR APPLIED FUNGICIDES

ACTIVE INGREDIENT	TRADE NAME
Anilazine	Dyrene
benomyl	Benlate
captafol	Difolatan
chlorothalonil	Bravo
fixed copper	Tri Cop, Chem Cop, Kocide 101
iprodione	Rovral
mancozeb	Dithane M45, Manzate 200
maneb	Manzate D, Dithane M22
metiram	Polyram
propiconazole	Tilt
triadimefon	Bayleton

Only Dithane M45 is registered for foliar application to wheat.

TABLE 3 — FOLIAR APPLIED FUNGICIDES

	ACTIVE INGREDIENTS	anilazine	benomyl	captafol	chlorothalonil	fixed copper	iprodione	mancozeb	maneb	metiram	propiconazole	triadimefon
LEAF RUST	Hard Red Spring Wheat							●				
	Semi Dwarf							●			●	
	Winter Wheat							●			●	●
	Barley										●	
STEM RUST	Hard Red Spring Wheat											
	Semi Dwarf										●	
	Winter Wheat										●	●
SEPTORIA	Hard Red Spring Wheat							●				
	Semi Dwarf							●			●	
	Winter Wheat							●			●	
	Barley										●	
TAN SPOT	Hard Red Spring Wheat							●				
	Semi Dwarf							●			●	
	Winter Wheat							●			●	
POWDERY MILDEW	Hard Red Spring Wheat											
	Semi Dwarf										●	
	Winter Wheat										●	●
	Barley										●	
NET BLOTCH SPOT BLOTCH, SCALD	Barley										●	
SCLEROTINIA	Canola		●		●		●					
	Field Bean		●		●		●					
BACTERIAL BLIGHT	Field Bean					●						
EARLY AND LATE BLIGHT	Potatoes	●		●	●	●		●	●	●		

Inoculation of Pulse Crops (field peas, lentils, field beans, fababeans, soybeans)

Pulse crops are legumes belonging to the same plant family as alfalfa and sweet clover. They have the capacity to capture atmospheric nitrogen, and transform it into useable plant nitrogen in the form of amino acids and proteins. This process is called "nitrogen fixation".

Nitrogen (N) fixation takes place in nodules attached to the roots of legumes. Nodules are large bundles of cells which form when Rhizobium bacteria invade the root hairs, shortly after germination. Rapid cell multiplication takes place to form the gall-like structures.

To ensure rapid development and optimum N-fixing activity, it is necessary to have sufficient numbers of bacterial (rhizobial) cells close to the seed. Often, soils do not contain rhizobia of the right types, or in sufficient numbers for the pulse crop being grown. Therefore, rhizobia must be added to the seed, or to the soil prior to seeding. This is called inoculation.

Inoculation Methods Two methods of inoculating pulse crops are recommended:

1. With peat-based powder inoculum added to the seed as a wet slurry. The seed should be treated as close to seeding as possible, and preferably include a "sticker" to improve the adherence of the inoculum to the seed coat.
2. With granular peat or clay-based inoculum added to the soil at the time of seeding.

   These methods ensure each seed is in contact with inoculant (rhizobial cells).

   For the sake of speed and convenience, dry powder inoculant is often mixed with the seed in the drill box. This method distributes the seed so unevenly that many seeds leave the drill box with insufficient inoculant adhering to them. *Uneven nodulation and reduced N-fixation is the result so that this method is not recommended.*

Specific Inoculant Specific inoculants for all pulse crops are available commercially.

It is essential that *the inoculant specific to the crop being sown* is applied. Check the inoculant package to ensure it is specific to the crop you are producing.

Expiry Date Packages should have an expiry date stamped on them, so a check can be made to ensure your inoculant is fresh. If it is purchased well before seeding, store in a cool, dark place (UV light rapidly kills the rhizobia). Apply inoculant to the seed immediately before seeding, and protect all treated seed from sunlight. Do not use old (last year's) inoculant.

Field Bean Inoculant For reasons not fully understood, field beans are the least infected by rhizobia. Some plants are very well nodulated, while others carry few if any nodules in spite of adequate inoculation. This has led some producers to add N fertilizer to field beans, in addition to, or instead of inoculating.

Check for Nodulation and Nodule Activity It is a good idea to check nodulation three to four weeks following emergence. Carefully dig up plants, preserving the finer roots, and look for nodules. Most nodules will be congregated around the main (tap) root. At this stage, they will be small but active. Nodules which are fixing nitrogen will be pink inside, and slicing the nodule with a knife or thumb nail will reveal this colour. The absence of the pink colour indicates an inactive nodule.

Crop Rotations

Alternating of broadleaf and cereal crops is generally recommended; specific cases are discussed under individual crop sections. Further information on crop rotation can be obtained from the Manitoba Agriculture 'Crop Rotation Chart'.

Table 1 details some common diseases of field crops in Manitoba. It indicates which diseases occur on more than one crop, and their longevity in the field when a susceptible host is absent.

Weed Control

Recommendations on weed control must be combined with proper identification of the problem, good cultural practices and crop rotation. Refer to Manitoba Agriculture's 'Guide to Chemical Weed Control' and 'Field Sprayers' publications.

For further information consult your Manitoba Agriculture representative, weed or crop specialist; the Plant Science Department, University of Manitoba; Agriculture Canada; the local weed supervisor; or chemical industry technical and sales representatives.

Guidelines for Successful Weed Control

- Clean, repair and calibrate the sprayer early in the season.
- Check the crop weekly, after emergence, to identify the weed problem.
- Use the correct herbicide.

- Apply herbicides at the proper stage for maximum weed control and crop safety.
- Use Amine formulations of 2,4-D or MCPA for greater crop safety, and to reduce the volatility hazard.
- Avoid spraying on windy days, particularly near susceptible crops.
- Always read and follow herbicide label instructions.
- Do not mix the chemicals unless stated on the label.
- Mix the herbicide solution in the spray tank for 15 minutes before starting to spray, by using the sprayer by-pass to circulate through the tank. The spray pump must have sufficient capacity to continue circulation through the by-pass during the spray operation.

Herbicide Residues

Some recommended herbicides leave a residue in the soil which may restrict cropping options for one or more years after application. See Manitoba Agriculture's 'Guide to Chemical Weed Control', and 'Crop Rotation Chart', plus product labels for detailed information.

Insect Pests

Information on control of insect pests of field crops and stored grain can be obtained from these Manitoba Agriculture publications:

- 'Control of Insects and Mites in Farm Stored Grain'
- 'Grasshopper Control in Manitoba'

Questions about other insects which may cause problems should be referred to Manitoba Agriculture or Agriculture Canada staff.

TABLE 4 — INSECT PESTS

Insect control information for pests listed below is available from the Manitoba Agriculture publication 'Insect Control in Field Crops'.

Grasshoppers.
Crops attacked: All crops.
Threshold level: Cereal and oilseed crops — 7-12/M^2 (yd^2).
Cultural control: Fall tillage may destroy some eggpods in fields.

Aphids.
Crops attacked: Cereal crops, flax, faba beans, peas, potatoes, canaryseed.
Threshold levels: Barley (prior to heading) — 50/Plant.
All cereals (after heading) — 50/Head.
Peas — 2-3 aphids/20 CM (8 in.) plant tip at flowering.
Faba beans — When 75% of the plants have at least one aphid.
Potatoes — When numbers exceed 30 per 100 leaves.
Canaryseed — No threshold levels determined.
Cultural control: none.

Cutworms.
Crops attacked: All crops.
Threshold levels: Cereal crops, Oilseeds, sunflowers — 3-4/M^2 (yd^2).
Cultural control: None.

Armyworms.
Crops attacked: Cereal crops.
Threshold level: 10/M^2 (yd^2).
Cultural control: None.

European Corn Borer.
Crops attacked: Field corn.
Threshold level: When 50% of the plants show shotholing in the leaf whorls.
Cultural control: None.

Bertha Armyworm.
Crops attacked: Canola, mustard, flax.
Threshold level: Canola, mustard — 20-30/M^2 (yd^2).
Cultural control: None.

Flea Beetles.
Crops attacked: Canola, mustard.
Threshold level: When 25% of leaf surface of seedling plants is destroyed.
Cultural control: None.

Diamondback Moth.
Crops attacked: Canola, mustard.
Threshold level: 30/0.1M^2 (ft^2)
Cultural control: None.

Sugarbeet Root Maggot.
Crops Attacked: Sugarbeets.
Threshold level: Not available.
Cultural control: Crop rotation, early seeding.

Colorado Potato Beetle.
Crops attacked: potatoes.
Threshold level: When leaf damage exceeds 10%.
Cultural control: None.

Potato Leafhopper.
Crops attacked: potatoes.
Threshold level: When numbers exceed 30/100 leaves.
Cultural control: None.

Sunflower Beetle.
Crops attacked: Sunflowers.
Threshold level: Adults — 1 beetle per 2 seedling plants.
Larvae — when populations exceed 10-12/plant.
Cultural control: none.

FERTILIZER USE

Most crops respond well to fertilizer when the available nutrient level of soil is low. Stubble fields are usually low in nitrogen and phosphorous. Fallow fields usually have adequate nitrogen but are low in phosphorous. Many fields may be low in sulphur and some may also be low in potassium. On the other hand, where high rates of fertilizer have been used for a number of years the level of available nutrients may be adequate to meet crop requirements.

Soil Testing

To determine the specific nutrient content of individual fields, have your soil analyzed. Obtain details of sampling procedures from your agricultural representative's office or your fertilizer dealer. Cost of routine testing ranges from $9 to $18 depending on test required. Send your sample to:

Provincial Soil Testing Laboratory
Ellis Building
University of Manitoba
Winnipeg, Manitoba R3T 2N2

For further details see Manitoba Agriculture factsheets 'Soil Testing Services in Manitoba' and 'Soil Testing — 14 Common Questions'.

On the basis of soil test results, fertilizer recommendations are provided. For all crops, a STANDARD SOIL TEST RECOMMENDATION is given which suggests a single application rate for each nutrient required as determined by the soil tests performed. These rates have been established to provide a good economic return from the fertilizer applied under reasonable Manitoba growing conditions.

For a number of common crops, TARGET YIELD FERTILIZER RECOMMENDATIONS are also provided which give an indication of rates of fertilizer nutrients that would have to be applied to meet the requirements of the crop over a range of potential yields. With this information producers have the flexibility of selecting a fertilizer application rate or Target Yield which best suites their individual situation.

Seed Placed Fertilizer

The recommendations for maximum fertilizer rates which can safely be applied with the seed have been established with granular fertilizers using double disc drill seeding equipment. Using this method, fertilizer is placed close to the seed. Discers, hoedrills and air seeders vary in their ability to accurately place seed and fertilizer. Use discretion in increasing recommended maximum rates of fertilizer with the seed if the contact between fertilizer and seed is less than that obtained with a double disc drill. The safe rate of fertilizer applied with the seed may also increase if fertilizer is applied in solution, rather than as granular fertilizer.

Major Nutrients For Annual Crop Production

Nitrogen Nitrogen fertilizer is effective in increasing both crop yield and protein content. Application at a rate of 75 kg/ha (67 lb/acre) or less to soils low in available nitrogen usually results in yield increases. When soil available nitrogen levels are high or more than 60 kg/ha (54 lb/acre) nitrogen is applied, both yield and protein content are increased.

The effectiveness of nitrogen in increasing yield and/or protein content is significantly affected by the time of application and method of placement. The various nitrogen carriers are about equally effective in increasing yields and/or protein content of annual crops when applied in a manner that minimizes nitrogen losses. The greatest efficiency of all nitrogen fertilizers is obtained when the fertilizers are banded into the soil at or near seeding, or applied in the seed row.

NOTE: The amounts of various nitrogen fertilizers which can be applied with the seed without seedling damage are given with the fertilizer recommendations for each crop. Urea, and liquid or dry fertilizers containing urea should be well covered with soil to minimize losses. Apply anhydrous ammonia and aqua ammonia at depths of 10 to 15 cm (4 to 6 in) and apply only when soil conditions permit a good seal behind the applicator shanks.

Relative Efficiencies of Time and Method of Nitrogen Application

The relative efficiency of nitrogen fertilizers as affected by the time of application and the method of placement varies greatly from year to year. Average relative values of times and methods of application when spring broadcast nitrogen is given a value of 100, has been calculated as follows:

Time and Method	Relative Values
Spring broadcast	100
Spring banded	120
Fall broadcast	82
Fall banded	93

NOTE: Broadcast values assume urea based nitrogen carriers are incorporated where necessary to minimize losses incurred through ammonia volatilization particularly on soils with a high pH or which contain free lime in the surface soil.

Banded values are based on any in-soil band application (including a with-the-seed band as long as the rate applied does not exceed the safe limit where damage to germination or seedling emergence may occur). The band must not be disturbed prior to or during the seeding operation.

Losses of nitrogen due to leaching, gaseous loss, immobilization and weed growth are probably higher for fall applied than for spring applied

nitrogen. This accounts for the differences in efficiencies between fall and spring indicated above.

These losses may be greater if the nitrogen is applied too early in the fall (prior to mid-September), or when soil temperatures at the 10 cm (4 in) depth are greater than 5°C.

For further details see Manitoba Agriculture factsheet 'Nitrogen Fertilization in Crop Production'.

Phosphorus Most Manitoba soils are phosphorus deficient and so give yield responses to phosphorus fertilizer application. The response to phosphorus by any crop is affected by factors such as:

- root development and distribution
- ability of the plant to take up soil and phosphorus fertilizer
- the method of phosphorus application
- the soil available phosphorus level
- soil type (soil texture, pH and carbonate content)
- soil water and temperature

Ideally, plants need a good supply of phosphorus close to the seed during the first month of growing and an adequate quantity of phosphorus in the soil for the rest of the season.

Placing sufficient quantities of phosphorus with the seed or close to the seed have been the traditional methods for phosphorus fertilizing annual crops in Manitoba. This has been found to satisfy both early growth requirements and provide a reserve of phosphorus for the balance of the growing season.

Increasing the amount of phosphorus applied annually above that normally recommended (banded or broadcast), will increase the soil available phosphorus. It could be increased to high or very high levels so that yields would not be significantly affected by deficiency. The number of applications or years of phosphorus fertilization required to increase soil available phosphorus to high or very high levels is unknown for most soils. Soil testing at regular intervals is a good way to monitor the level.

CAUTION: High rates of applied fertilizer phosphorus (annual rates in excess of 150 kg/ha (134 lb/acre) P_2O_5 may induce a micro-nutrient deficiency if soil levels of micro-nutrients are marginal (for example, zinc and copper).

Phosphorus Banded With The Seed Banding of fertilizer phosphorus with the seed results in the greatest yield increase per unit of phosphorus for all crops, providing the amount applied does not injure the germinating seedling. Crops such as cereals will tolerate all their fertilizer phosphorus requirements placed with the seed.

Phosphorus Banded Near The Seed Banding fertilizer phosphorus near the seed (beside and/or below) results in the greatest yield increase per

unit of phosphorus when amounts in excess of those tolerated with the seed are required. Phosphorus placed in this manner is recommended for most oilseeds, annual legumes and row crops.

Phosphorus Deep-banded Deep-banded phosphorus [phosphorus banded at the 10 to 15 cm (4 to 6 inches) soil depth and in spacings of 30 cm (12 inches) or less prior to seeding] is more effective in increasing yields than phosphorus broadcast and incorporated. Nitrogen applied with the phosphorus will increase fertilizer phosphorus availability. Band these fertilizers together when both nitrogen and phosphorus are needed. Application of 10 to 15 kg P_2O_5/ha (9 to 13 lb/acre) with or near the seed may also be required to ensure adequate supplies of phosphorus for early growth.

NOTE: Bands must not be disturbed during tillage and seeding operations.

Phosphorus Surface Applied and Incorporated Surface incorporation of fertilizer phosphorus results in the lowest yield increase per unit of phosphorus. The amount broadcast must be greater than the amount applied with or near the seed to obtain equal yield increases in the year of fertilizer application. Since the amount of broadcast phosphorus used during the first number of years has to be increased two or fourfold to equal yield increases from placement near the seed, broadcast application of phosphorus may be uneconomic on many soils.

For additional information see the Manitoba Agriculture factsheets 'Phosphorus Fertilization in Crop Production' and 'Phosphorus Application for Annual Crops'.

Potassium Most Manitoba soils contain sufficient available potassium for crop production. Soils likely to contain insufficient potassium are the coarse textured (sands to sandy loams) and organic soils. Additional potassium may be required on about five to seven per cent of arable Manitoba soils for maximum production of the commonly grown annual crops such as cereals, rapeseed, and flax; on 25 to 40 per cent of soils for the production of the special annual crops such as corn, potatoes, sugarbeets and the horticultural fruit or vegetable crops. Where required, potassium can increase crop yield and quality. Depending on the type of crop, it may increase frost and disease resistance, palatability, storage, quality, etc. A soil test is recommended to determine whether a potassium application is warranted in any specific situation.

For the most efficient use by annual crops, potassium fertilizers should be placed in the seed row or side banded whenever possible (within limits allowable for each crop). The method and amount of potassium application for specific crops is given with the general fertilizer recommendations for each crop. The efficiency of broadcast potassium is one-half or less that of potassium applied with the seed or side-band. If potassium is being broadcast, the rate recommended for seed placement or side banding should be doubled to obtain equal crop response. If broadcast, incorporate potassium fertilizer into the soil.

Sulphur Well drained soils and grey luvisol (grey wooded) soils are susceptible to sulphur deficiency. Sulphur deficiency may occur in many other soils and in any area of the province. As a result, soil testing is recommended to establish the available sulphur status of your fields.

Available sulphur levels can vary greatly from location to location within a field. When fields are being soil sampled, attention should be paid as to where and the number of samples which are taken. On rolling ground, samples should be taken from the mid-slope area to give an idea of average field sulphur levels. On level land, samples should be taken from the best drained positions in the field. An adequate number of sites should be sampled in order to obtain a composite sample which is truly representative of the field.

Crops vary greatly in their sulphur requirements. Canola (Rapeseed), mustard, corn, potatoes, sugarbeets, horticultural crops, and forages containing a legume component, have a higher sulphur requirement than cereal grains or flax.

Sulphur deficiencies are more likely to occur in crops having a high sulphur requirement. These crops also have a greater tendency to deplete the sulphur for subsequent crops. This is particularly true following breaking of a perennial forage stand.

Sulphur fertilizer recommendations are based only on sulphur being applied in the sulphate or oxidized (SO_4) form. This is the only form readily available to plants. Some nitrogen and phosphorus fertilizers contain sulphate sulphur, i.e. 20-0-0 (24) and 17-20-0 (15). Ammonium thiosulphate, 12-0-0 (26), is a liquid formulation containing 26 per cent sulphur by weight. One-half of the sulphur converts into the readily available sulphate form, and the remainder into finely divided elemental sulphur. This product can be applied to supply sulphur at the rate recommended for sulphate sulphur. Since sulphate sulphur is usually in combination with nitrogen and phosphorus it may be broadcast, banded or seed placed (as long as the safe limits for seed placed nitrogen and phosphate are not exceeded for the specific crops).

Sulphur in the elemental form, as it occurs in some high analysis sulphur products such as flaked or prilled elemental sulphur (99% S), flowers of sulphur (99% S) or granular sulphur (90% S) becomes available to plants when oxidized to the sulphate form. When elemental sulphur is used it should be broadcast and incorporated well ahead of the time it would be required by the crop.

Oxidation of sulphur requires time, and depends on soil temperature and moisture, size of sulphur granules and the rate at which granules break down in the soil. Recent research has found that sulphur from these products does not become available in sufficient quantities to meet crop requirements in the year of application. They are not recommended for soils with a low available sulphur content, where the crops would require the applied sulphur to be available in the year of application.

Micro-Nutrients

The majority of mineral soils in Manitoba contain sufficient micro-nutrients for most crops. Farmers should not apply micro-nutrient fertilizers unless deficiencies have been established through consultation with extension agronomists, a soil analysis and/or tissue analysis, and small scale trials.

The Manitoba Soil Testing Laboratory offers a soil micronutrient analysis service. The copper-zinc-iron-manganese soil analysis will be done when requested for $8 per field above the cost of the routine soil test. Proper soil sampling and sample handling procedures are important.

Additional information is available in the Manitoba Agriculture factsheet 'Micro-nutrients in Crop Production'.

Plant Tissue Analysis

The Manitoba Soil Testing Laboratory offers a plant tissue analysis service. Plant tissue analysis measures the nutrient levels in growing crops. Test values are then compared to established values for inadequate, adequate and excess for each element and plant specie. In this way the nutritional health of the plant sample and the crop it represents can be assessed, and the supply and availability of nutrients to crops during the growing season can be evaluated.

Plant tissue analysis then is useful in evaluating fertilizer management programs and practices, diagnosing nutrient related crop production problems, and identifying nutrient levels in crops that may limit top yield achievement. It is also useful in evaluating and identifying potential micronutrient problems.

Cost ranges from about $6.00 per sample for a nitrogen only analysis to about $18.00 for a complete 10 nutrient analysis. Proper plant sampling and sample handling procedures are important. Detailed information on plant tissue analysis and complete instructions for sampling are contained in the Manitoba Agriculture factsheet 'Plant Tissue Analysis'.

Organic Soils

Crops such as barley, oats, canola (Polish type) and grasses perform better than wheat and flax due to the colder micro-climate on organic soils.

Most organic soils are very deficient in phosphorous and potassium. Farmers on organic soils should use the higher rates of phosphate and potassium recommended in this publication for each crop.

Organic soils are frequently deficient in copper and may also be deficient in manganese and boron. Copper deficiencies are more likely on organic soils (at least 60 cm or 24 inches in depth) and manganese deficiencies on the shallower organic soils (less than 36 cm or 14 inches) which are over a high lime mineral subsoil. Use both soil and plant analyses as aids in determining if these micro-nutrients are deficient. Conduct small scale trials (micro-nutrients applied to portions of a field) to assess the effects of micro-nutrient fertilizers on crop yields before using large areas. Recommendations for micro-nutrient fertilizer use in these trials and in instances where deficiencies exist are:

Copper: Three different copper fertilizers are on the market. These are copper sulphate, sequestered copper and EDTA copper chelate. Copper sulphate is applied by broadcasting whereas the sequestered and EDTA chelate are handled much like herbicides. Producers interested in treating copper deficiency problems on organic soils may try the following:

a) Copper Sulphate — Broadcast 44 kg/ha (40 lb/acre) of copper sulphate and incorporate. Fall application may be more effective than spring application. Applying copper sulphate at this rate may provide a residual effect for several years.

b) 7.5% Copper EDTA Chelate — Spray and incorporate 5.5 L/ha (2 quarts/acre) prior to seeding.

c) 7.5% Copper EDTA Chelate — If copper deficiency is noted very early in the growing season, in order to salvage the crop producers may try 2.8 L/ha (1 quart/acre) EDTA as a foliar application.

d) Sequestered Copper 5% — Spray and incorporate 5.5 L/ha (2 quarts/acre) prior to seeding. Yields may be less than with EDTA.

When working with copper sulphate, safety precautions such as wearing a dust mask and goggles, working upwind from the applicator and washing hands before eating should be observed. Because copper sulphate is very corrosive, equipment should be washed immediately after application.

Additional information is available in the Manitoba Agriculture factsheets: 'Introduction to Peat Soil Management' and 'Crop Management on Peat Soils'.

Manganese: 10 to 15 kg/ha (9 to 13 lb/acre) manganese, (for example, 40 to 60 kg/ha (36 to 54 lb/acre) manganese sulphate) should be drilled with the seed of cereals and banded away from the seed of rapeseed and grasses.

Boron: Incorporate 1 to 2 kg/ha (1 to 2 lb/acre) boron, (for example, 9 to 17 kg/ha (8 to 15 lb/acre) borax) with the surface 15 cm (6 in) of soil.

Additional information is contained in the Manitoba Agriculture factsheet 'Micro-nutrients in Crop Production'.

Calculation of Fertilizer Rates Fertilizers are labelled by percentage according to their guaranteed minimum analysis in terms of nitrogen (N), phosphate (P_2O_5) and potash (K_2O). For example, 16-20-0 (14) contains 16 per cent nitrogen by weight, 20 per cent phosphate by weight, 0 per cent potash by weight, and approximately 14 per cent sulphur by weight. The actual weight of nutrients in 100 kg (220 lb) fertilizer is: N = 16 kg, (35 lb), P_2O_5 = 20 kg (44 lb) and K_2O = 0.5 kg, (1.1 lb.) and S = 14 kg (31 lb) approximately.

For example:

1. Using 34-0-0
   Rate of N desired = 45 kg/ha (40 lb/acre)

   $$\text{Rate of fertilizer required} = \frac{45 \times 100}{34} = 132 \text{ kg/ha}$$

   $$= \frac{(40 \times 100)}{(34)} = (117 \text{ lb/acre})$$

2. Using 16-20-0-14
   Rate of P_2O_5 desired = 22 kg/ha (20 lb/acre)

   $$\text{Rate of fertilizer} = \frac{22 \times 100}{20} = 110 \text{ kg/ha}$$

   $$= \frac{(20 \times 100)}{(20)} = (100 \text{ lb/acre})$$

   110 kg/ha (100 lb/acre) of 16-20-0(14) would also supply nitrogen at the rate of

   $$\frac{16 \times 110}{100} = 17.6 \text{ kg/ha} \; ; \; \frac{(16 \times 100)}{(100)} = (16 \text{ lb/acre})$$

   and sulphur at the rate of

   $$\frac{14 \times 110}{100} = 15.4 \text{ kg/ha} \; ; \; \frac{(14 \times 100)}{(100)} = (14 \text{ lb/acre})$$

Additional information is contained in the Manitoba Agriculture fact-sheet 'Calculating Nutrient Costs and Fertilizer Rates'.

TABLE 5 — COMMON FERTILIZERS

NOTE: The number in brackets denotes the approximate percentage of sulphur in the fertilizer.

FERTILIZER	Liquids (solutions)
Ammonium phosphate	10-34-0
Nitrogen solution	28-0-0
Aqua ammonia	20-0-0
Ammonium thiosulphate	12-0-0-(26)
Ammonium thiosulphate and nitrogen solution	15-0-0(20)
Phosphoric Acid	0-52-0
	Gas (compressed)
Anhydrous ammonia	82-0-0
	Dry (solids)
Ammonium phosphate	10-50-0 to 11-55-0
Ammonium phosphate sulphate	16-20-0(14)
Diammonium phosphate	18-46-0
Ammonium nitrate phosphate	24-22-0, 28-13-0
Urea ammonium phosphate	27-27-0; 34-17-0
Ammonium sulphate	21-0-0-(24); 20-0-0(24); 17-20-0(15)
Ammonium nitrate phosphate sulphate	26-13-0(3)
Ammonium nitrate	34-0-0
Urea-ammonium sulphate	34-0-0(11)
Urea Sulphur (elemental)	36-0-0(20)
Urea	46-0-0
Potassium chloride	0-0-60; 0-0-62
Potassium sulphate	0-0-50(18)
Sulphur (elemental)	0-0-0(90)

In addition to these premixed fertilizers, micro-nutrients and specially blended fertilizers including suspensions are available from some fertilizer dealers.

Erosion Control

Sufficient crop residue must be left on the soil surface to prevent erosion during the crucial period when there is insufficient crop growth to provide adequate protection.

Table 6 indicates the amount of various crop residues for different soil textures required for wind erosion protection.

TABLE 6 — CROP RESIDUE REQUIREMENTS FOR WIND EROSION CONTROL

Texture	Small Grains (flat straw)	Grain Corn, Sunflower (standing stalks)	Canola, Flax (standing straw)	Grain Corn (flat straw)
	kg/ha (lb/acre)			
very fine; fine & medium sands, dune sands	1900-2200 (1700-2000)	2800-3400 (2500-3000)	3200-3900 (2900-3500)	4600-5600 (4100-5000)
loamy sands; loamy fine sands	1200-1600 (1100-1400)	1900-3400 (1700-2100)	2300-2700 (2100-2400)	3400-3900 (3000-3500)
very fine sandy loams; fine sandy loams, sandy loams	1000-1300 (900-1200)	1100-1600 (1000-1400)	1800-2200 (1600-2000)	2500-3100 (2200-2800)
clay, silty clays, non-calcareous clay loams & silty clay loams	700-1100 (600-1000)	900-1800 (800-1600)	1200-2000 (1100-1800)	1700-3100 (1500-2800)
calcareous loams & silt loams, calcareous clay loams & silty clay loams non-calcareous loams, silt loams, sandy clay loams & clay loams	200-560 (200-500)	450-780 (400-900)	450-1000 (400-900)	900-1300 (800-1200)

For water erosion control, Table 7 shows the recommended residue requirements according to per cent slope.

TABLE 7 — SLOPE AND RECOMMENDED QUANTITY OF RESIDUE

% Slope	Description	Residue** kg/ha (lbs/acre)
6 - 9	gentle slopes	780 - 1100 (700 - 1000)
10 - 15	moderate slopes	1100 - 1700 (1000 - 1500)
16 - 30	steep slopes	continuous grass and forage
+30	very steep slopes	native vegetation

**Refers to annual crops.

The amount of crop residue which is left to cover the soil surface after fall tillage also affects soil moisture. As a general rule, the moisture content of a soil will increase as more residue is left on the surface. The residue absorbs the force of the rain drops and as a result reduces surface crusting. This enables a greater infiltration of rainwater. It also reduces the loss of soil water by evaporation and traps snow in the winter.

Tillage is one farming practice which has a direct influence on the amount of residue left on the soil surface to combat erosion and build up soil moisture reserves. Use of tillage equipment buries crop residue and reduces its effectiveness in soil and water conservation. Table 8 shows the amount of trash buried by various tillage implements.

TABLE 8 — EFFECT OF SEVERAL TYPES OF TILLAGE IMPLEMENTS ON RESIDUE COVER

Implement	Amount Of Straw Buried With Each Pass %*
Wide Blade Cultivator [sweeps 95 cm (37 inches) or wider]	10
Rodweeder	10
Field Cultivator	10 - 20
Heavy Duty Cultivator	20 - 30
One-Way Disc	40 - 50
Heavy Tandem or Offset Disc	35 - 65
Plow	90

*Residue reduction will vary depending on depth and speed of operation.

Minimum Tillage

Minimum tillage refers to the least amount of tillage required to create the proper soil conditions for seed germination and plant establishment. Minimum tillage can be considered conservation tillage if sufficient crop residues are left on the soil surface to provide erosion protection.

Zero Tillage

Zero tillage involves the planting of a crop into untilled stubble land with minimal soil disturbance and chemical weed control.

Research trials and farmer experience have shown that zero tillage provides an alternate method of production for wheat, barley, flax, and rapeseed where tillage reduction is desirable to conserve moisture, reduce soil erosion, reduce fuel and labor inputs, and reduce numbers of annual weeds. Zero tillage can be practised on most soil types. However, wet heavy clay soils may cause difficulties in seeding resulting in inadequate crop stands.

Field experience has shown that trash management and fall weed control are extremely important the fall before zero tillage crop production.

Continuous cropping with the same crop can lead to a build-up of soil-borne diseases, so crop rotation is recommended. Zero tillage may result in an increased risk of diseases that are partially controlled by incorporating the stubble.

The following operations are included in zero tillage crop production.

Fall

1. Crop Residue Management Straw and chaff must be removed or chopped and evenly distributed in the fall to allow for proper seed placement.

2. Weed Control Perennial weeds (quackgrass, Canada thistle and perennial sow thistle) and winter annual weeds (stinkweed, shepherd's purse, and flixweed) must be controlled in the fall.

3. Soil test A soil test is required to accurately determine fertility requirements.

Spring

1. Fertility Fertilize zero tilled crops according to soil test recommendations. Place maximum allowable amounts of nitrogen, phosphorus and potassium with the seed. If the drill being used has side-banding capability, the remaining nitrogen may be banded away from the seed. A preplant banding of nitrogen may be efficient, but will increase soil disturbance. Broadcast applications of nitrogen may also be efficient if rainfall occurs to carry the fertilizer into the soil. Loss of nitrogen from broadcast urea-based fertilizers may be substantial if applied during hot, dry weather.

2. Seeding Seed should be placed 2 to 3 cm (0.8 to 1.2 in) into moisture using a modified press drill or a commercial zero tillage drill. Minimize soil disturbance to avoid unnecessary weed germination.

3. Initial Weed Control All weed growth present at the time of seeding must be controlled. Herbicide can be applied prior to seeding or between seeding and crop emergence. Application before seeding eliminates the risk of weather delaying spraying past crop emergence. Application after seeding, but prior to crop emergence, maximizes weed control by allowing more weeds to emerge.

4. Weed Control In The Crop Selective weed control in the crop depends on postemergent herbicides. Crops which cannot be treated with postemergent herbicides should not be considered for zero tillage.

Specific weed control recommendations are listed in the Manitoba Agriculture 'Guide to Chemical Weed Control'.

GRAIN DRYING AND STORAGE OF DAMP GRAIN

Aeration

Aeration is the use of relatively low airflow rates to cool grain and eliminate temperature and moisture differences in the storage bin. Aeration may be used with field dried grain or with grain that is harvested damp, then dried and cooled in a heated air dryer. In both cases, temperature and moisture content variations may exist in the grain, or the grain may be too warm to store safely. Variations in grain temperature are also caused by changes in the outside air temperature after the grain is stored.

patterns when temperature differences are created by lower surrounding temperatures. Warm air rising in the centre of the bin cools when it reaches the cold grain near the surface. This results in an increase in moisture content near the surface which can lead to rapid spoilage. Crusting on the surface of stored grain is a common symptom of moisture migration. Significant migration can occur in cereal grains at moisture contents as low as 12 per cent or oilseeds as low as 8 per cent if they are placed into storage at a high temperature and not cooled.

FIGURE 2 MOISTURE MIGRATION IN STORED GRAIN — FALL & WINTER.

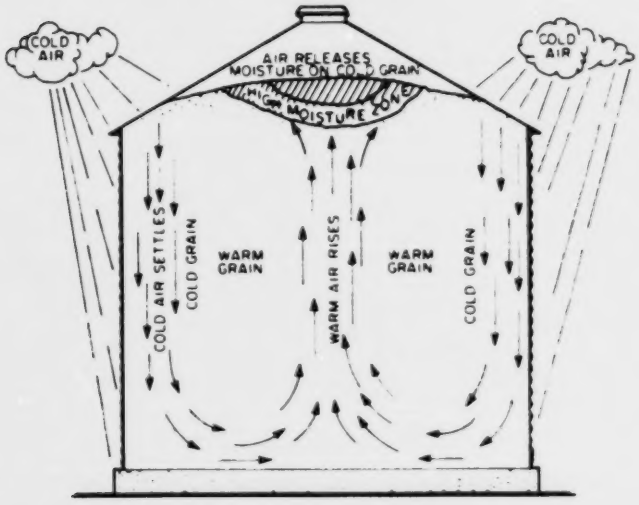


TABLE 9 — SUMMARY OF BASIC RECOMMENDATIONS FOR DRYING AND COOLING PROCESSES

Process	% above "dry"*	Recommended airflow rates $(L/s)/m^3$	Recommended Minimum perforated floor area	Transfer for final storage
Aeration	0	1-2	15%	No
Unheated Air Drying	1-6	5-30	100	No
Dryeration	2-3	5-10	40	Yes
			100	No
In-Storage Cooling	1	5-10	40	No

*% above "dry" is the number of moisture percentage points above "dry" at which the grain is placed into the bin. Example: For dryeration, wheat is placed into the bin at up to 17% moisture (14.5 + 2.5 = 17%).

Satisfactory performance of an air handling system depends on the selection of proper equipment, adequate sizing, proper installation, and good management. Three requirements must be met to ensure proper performance.

1) Selection of a fan or combination of fans that deliver the required air flow at the necessary static pressure
2) Proper sizing and arrangement of the perforated duct surface area or perforated floor area to deliver the air uniformly
3) Proper sizing (cross-sectional flow area) of the ducts, fan transition, and bin exhaust vents.

The entire design procedure is available in a computer program which calculates the airflow and static pressure requirements for various grains, airflow rates, bin diameters and grain depths. It will also select suitable fans by make and model. The program can predict airflow rates for any given fan, bin and grain combination, and simulate drying for wheat, barley and canola. The computer program can be accessed at any of the following agricultural engineering offices in Manitoba:

Dauphin —	638-9111	Arborg —	376-5212
Brandon —	728-5724	Beausejour —	268-1411
Portage —	857-9711	Winnipeg —	945-3862

Heated-Air Grain Dryers

Advantages of Grain Drying *Longer Harvest Season* — A grain dryer can substantially increase the number of available harvesting hours and days in most areas, and could also reduce the overall investment in machinery. A smaller combine plus a dryer could be used instead of buying a second combine or trading up to a larger one. For a farmer relying on custom harvesting, a grain dryer can be helpful in getting his harvesting done early.

Earlier Harvesting — Earlier harvesting is possible when a grain dryer is used. Wheat, oats and barley can be threshed at 20% moisture content (MC) and then dried without loss of quality, grade or germination. When compared with harvesting at 14%, there may be a difference of only 1 or 2 days in mid-August, but by mid-September it may be 4 days or more. If a wet spell occurs, the differences could be much greater. Early harvesting may allow a farmer to harvest nearer to the maximum 'dry' moisture content, which results in the highest weight of grain for sale. Harvesting early also allows a farmer to do a better job of weed control through timely chemical application and tillage practices.

Reduced Field Losses — Weather damage and losses caused by wildlife can be reduced by harvesting at the tough[1] or damp[2] stages. A loss of one grade may mean a 5% loss in price and a 5% loss in weight, for a total loss of 10%. Harvesting before, instead of after, a rainy spell can therefore result in a considerable saving. Overdrying of crops in the field, which leads to shattering and crop loss, can also be prevented by earlier harvesting. Straight combining of some crops, such as sunflowers and corn, is a necessity and if these crops are harvested damp, field losses are greatly reduced. A dryer in the system may also make it feasible to straight combine other crops. Replacing a windrower with a dryer is therefore an alternative that should be considered.

Eliminate Spoilage in Storage — When tough or damp grain is harvested and not dried, long-term storage frequently results in grain spoilage. Moisture migration within grain bins can make slightly tough or even dry grain unsuitable for storage. Spoilage problems caused by hot spots and insect infestations can be reduced or eliminated by proper drying and aeration in storage.

The initial cost of a dryer is one of the major deterrents to grain drying. Where only small amounts of grain are to be dried each year, the initial cost should be a primary consideration. Where large amounts of grain are dried, fuel efficiency becomes the most important factor.

The labor and inconvenience of drying are also deterrents on many farms where no centralized grain-storage facility exists. To obtain maximum benefits from a grain dryer, it is necessary to set up a well-organized system for grain handling and storage.

Testing for Heat Damage Various tests may be conducted to find the highest acceptable drying temperatures for a particular grain and dryer. If the grain is to be used for seed, a germination test should be used. In addition, a sample of the grain should be taken before drying for testing to help determine whether there was any change in the germination rate during the drying process. Commercial grains other than for seed (milling wheat, malting barley and oilseeds) are tested free of charge for heat damage by the Canadian Grain Commission. Two samples (minimum of 500 g each), one taken before and one after drying, should be sent to the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, Man. The samples should be representative of the grain going in and coming out of the dryer. If the grain quality is unchanged, a higher temperature can be tried and two more samples sent in for testing. Several companies which purchase oilseeds, corn, and grain for seed also conduct tests for heat damage. Check with the purchaser at the start of drying to ensure that the dried grain meets their standards.

1. *Tough = mc values between those given in Table 10 and 17% for cereal grains or 13% for oilseeds.*
2. *Damp = mc above 17% for grain and above 13% for oilseeds.*

TABLE 10 — MAXIMUM STORAGE MOISTURE CONTENTS

Crop	Moisture %	Crop	Moisture %
Wheat	14.5%	Rapeseed	8.5%
Barley	14.8	Corn	15.5
Oats	14.0	Peas	16.0
Rye	14.0	Sunflowers	9.5
Flax	10.5	Mustard	11.0
Buckwheat	16.0	Canary seed	12.0

TABLE 11 — MAXIMUM DRYING TEMPERATURES

Crop	Seed or malting	Commercial use	Feed
Wheat	60°C	65°C	80 - 100°C
Oats	50	60	80 - 100
Barley	45	55	80 - 100
Rye	45	60	80 - 100
Corn	45	60	90 - 100
Flax	45	80	80 - 100
Rapeseed	45	65	—
Peas	45	70	80 - 100
Mustard	45	45	—
Sunflowers	45	50	—
Buckwheat	45	45	—

Storage Moulds

Storage moulds are types of fungi that are associated with detrimental changes in grain appearance and quality in storage. A by-product of some types of storage moulds are mycotoxins such as Ochratoxin, which are poisonous to humans and animals. Infections by storage fungi are promoted by warm temperatures, seed injury, green crop or weed debris, and especially moisture. To control storage moulds, grain should be stored at a moisture content less than 14%. Grain in storage should be monitored periodically for evidence of heating, an indication of mould growth.

Prevention and Control of Insects and Mites in Farm Stored Grain

Identification The principle types of pests found in farm stored grain are fungus feeding and grain feeding pests. Identification characteristics of both include:

Fungus Feeding Pests These include fungus beetles, grain mites and psocids. They do not live in sound, dry grain and their appearance indicates grain going out of condition.

FIGURE 3 — FUNGUS FEEDING PESTS

Prevention Measures

- Clean up and burn or bury any grain spilled when bins are filled or emptied. Spillage is an excellent breeding site for grain insects.
- To prevent insect breeding, destroy residues after grain has been removed from piles or temporary storages.
- Initiate a granary clean-up program that includes:
  - — repairs and weatherproofing
  - — cleaning and burning or burying sweepings to prevent insect breeding
  - — thoroughly spraying the granary with a mixture of 60 mL (½ pt) malathion 50% EC in 4 L (1 gal) water. Apply the mixture at a rate of 5 L/100 m² (1 gal/1,000 sq ft) or to the point of runoff.
- Frequently examine stored grain for signs of crusting or spoiling and break any crusted areas
- Place metal rods into the core of bulk stored grain and inspect every 3 to 4 weeks for signs of heating

Control Measures for Fungus Feeding Pests Be sure the grain is in good storage condition by:

- removing crusted areas and hot spots
- burning or burying discarded grain
- drying grain, if necessary

Chemical control of fungus feeding pests is not necessary since they cannot survive in sound, dry grain.

CEREAL CROPS

BARLEY

Seeding

Dates May 1 to May 31. On the average, highest barley yields and optimum quality are obtained when the crop is planted early. Planting in late May or early June can result in significant yield reductions.

Rates 65 to 120 kg/ha (1.25 to 2.25 bu/acre). Circumstances requiring heavier rates of seeding include reduced germination, large seed size, abundant moisture reserves, and rough land preparation. The seeding rate for 2-rowed barley varieties should be increased by 25 per cent because of kernel size.

Depth 4 to 5 cm (1.5 to 2 inches). Seeding below 5 cm (2 in) results in weaker plants and may result in poor emergence.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

For most efficient use of the fertilizer, place all phosphate, potash, and nitrogen in the seed row, when possible. Total seed-placed fertilizer should not exceed 195 kg/ha, (174 lb/acre). Up to 45 kg/ha, (40 lb/acre) nitrogen, and not more than 20 kg/ha (18 lb/acre) nitrogen in urea form, may be placed with the seed.

Urea or urea-P should not be placed with the seed on coarse textured soils nor with the seed on any soil under dry seedbed conditions. Place any additional fertilizer required away from the seed. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur, particularly on sandy soils or under dry soil conditions.

Nitrogen Fertilization for Malting Barley

For a recommended malting barley to be acceptable for a malting grade, the grain should contain 10 to 12% protein. Soil test nitrate nitrogen to the 60 cm (two foot level) plus half the fertilizer nitrogen to be applied, should not exceed 90 kg N/ha (80 lb N/acre).

TABLE 12 — BARLEY - GENERAL RATE OF NUTRIENT

Barley to be grown on	Nitrogen (N)(1) kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-30	0-27	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	30-60	27-54	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	60-100	54-89	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O).

(4) Low sulphur levels can occur in any Manitoba Soil. When required, apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Potential Insect Pests

Grasshoppers, aphids, cutworms, armyworms are potential barley insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Smuts Treat seed of varieties listed as having fair resistance to loose or surface borne smuts (covered and false loose) with a suitable fungicide every three years. Varieties with poor resistance should be treated every two years. See Table 2.

Leaf Spots Fungi which cause leaf spot diseases of barley overwinter on barley straw, stubble, and seed. Treat seed from infected fields to reduce seedling infection. Planting barley after barley enhances the potential severity of net blotch, spot blotch and speckled leaf blotch (Septoria). See Table 1 for more information on choice of crops in a rotation. See Table 3 for a list of foliar fungicides for disease control.

Ergot If ergot has been a problem, rotate with a non-susceptible crop for one year to reduce disease incidence (see Table 1). Cultivate fields after harvest to bury ergot bodies to a depth of at least 5 cm (2 inches) and mow grass headlands and roadsides before heading to reduce ergot spread. If the seed source is known to contain ergot bodies, storage for more than one year reduces their viability to almost zero. Levels of ergot bodies in the harvested grain above 0.1 per cent may be toxic in livestock feed.

Harvesting

Particular care must be taken when harvesting malting barley, otherwise a promising standing crop may end up in the feed grades. Give close attention to the following:

- To promote fast drying, swath in compact windrows laid on stubble about one-third the height of the standing crop. The head should not come in contact with the ground.
- Adjust the combine several times during the day if necessary to prevent cracking and peeling. This generally means a slower cylinder speed than used for wheat, oats, or feed barley. Have the concave clearance adjusted to suit conditions; wider clearances are usually required at midday when the grain is driest.
- Avoid using damaged grain augers and elevators which can cause broken and peeled kernels.
- Highest yields are obtained when swathing is done with a kernel moisture content of about 35 per cent. The kernels are then firm but easily dented with the thumb nail.

OATS

Seeding

Dates May 1 to June 10. Oats give best returns when sown early.

Rates 55 to 115 kg/ha (1.5 to 3 bu/acre). Circumstances requiring heavier rates of seeding are large seed size, low germination, late seeding, weeds, wireworms, abundant moisture reserves, heavy textured soils, high soil fertility, deep seeding, and rough seedbed.

Depth 4 to 7 cm (1.5 to 3 inches).

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

For most efficient use of the fertilizer, place all phosphate, potash and nitrogen in the seed row when possible. Total seed-placed fertilizer should not exceed 195 kg/ha (174 lb/acre). Up to 45 kg/ha (40 lb/acre) nitrogen, and not more than 20 kg/ha (18 lb/acre) nitrogen in urea form, may be placed with the seed.

Urea or urea-P should not be placed with the seed on coarse textured soils nor with the seed on any soil under dry seedbed conditions. Place any additional fertilizer required away from the seed. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur particularly on sandy soils or under dry soil conditions.

TABLE 13 — OATS - GENERAL RATE OF NUTRIENT

Oats to be grown on	Nitrogen (N)(1) kg/ha	Nitrogen (N)(1) lb/acre	Phosphate (P_2O_5) kg/ha	Phosphate (P_2O_5) lb/acre	Potash (K_2O) kg/ha	Potash (K_2O) lb/acre	Sulphur (S) kg/ha	Sulphur (S) lb/acre
Fallow or legume breaking (2)	0-30	0-27	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	30-60	27-54	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	60-100	54-89	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O).

(4) Low sulphur levels can occur in any Manitoba soil. When required, apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Potential Insect Pests

Grasshoppers, aphids, cutworms and armyworms are potential oat insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Early seeding and heavier seeding rates will reduce damage by barley yellow dwarf virus, a disease which can attack all cereal crops.

Harvesting

Highest yields are obtained by swathing when the kernel moisture content is about 35 per cent. The greenest kernels (groats) at this stage have just changed from green to cream coloured. To obtain highest milling grades, dehulled kernels must be avoided. This may involve a slower cylinder speed and wider concave clearances.

RYE

Seeding

Dates Fall Rye — August 25 to September 15
Spring Rye — May 1 to May 30

Rates 45 to 95 kg/ha (0.75 to 1.5 bu/acre). High rates of seeding should be used with larger seed size, poor germination, weed competition, and poor seedbed conditions.

Depth 2.5 to 5 cm (1 to 2 inches). Seeding deeper than 5 cm (2 in) may result in decreased emergence and weak plants, causing severe winter kill in fall-seeded varieties.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 in) and 15 to 60 cm (6 t . 24 in).

For most efficient use of the fertilizer, place all phosphate, potash, and nitrogen in the seed row, when possible. Total seed-placed fertilizer should not exceed 195 kg/ha (174 lb/acre). Up to 45 kg/ha (40 lb/acre) nitrogen, and not more than 20 kg/ha (18 lb/acre) nitrogen in urea form, may be placed with the seed. Rates of nitrogen above those that can be safely applied with the seed should be broadcast in the spring.

Urea or urea-P should not be placed with the seed on coarse textured soils or with seed on any soil under dry seedbed conditions. Place any additional required fertilizer away from the seed. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur, particularly on sandy soils or under dry soil conditions.

TABLE 14 — RYE - GENERAL RATE OF NUTRIENT

Rye to be grown on	Nitrogen $(N)_{(1)}$ kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-20	0-18	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	20-45	18-40	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	45-70	40-62	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast in the spring. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O).

(4) Low sulphur levels can occur in any Manitoba Soil. When required, apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Potential Insect Pests

Grasshoppers, aphids, cutworms and armyworms are potential rye insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Seed Rot and Seedling Blights Rye seed should be treated with a suitable seed protectant to reduce seed rot, seedling blights and stem smut. See Table 2 for additional information.

Ergot For ergot problems, rotate with a non-susceptible crop for one year to reduce incidence (see Table 1). Cultivate fields following harvest to bury ergot bodies to a depth of at least 5 cm (2 inches) and mow grass headlands and roadsides before heading to reduce spread. If the seed source is known to contain ergot bodies, storage for more than one year will reduce their viability to almost zero. Levels of ergot bodies in harvested grain above 0.1 per cent may be toxic in livestock feed.

TRITICALE

Seeding

Dates April 15 to May 15. Triticale must be sown as early as possible for maximum yields.

Rates 125 kg/ha — 185 kg/ha (2 to 3 bu/acre) depending on seed size.

Depth 5 cm (2 inches). Triticale should not be placed deeper than 5 cm (2 in) as decreased emergence and weaker plants may result.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 in) and 15 to 60 cm (6 to 24 in).

For most efficient use of the fertilizer, place all phosphate, potash, and nitrogen in the seed row when possible. Total amount of seed-placed fertilizer should not exceed 195 kg/ha (174 lb/acre). Up to 45 kg/ha (40 lb/acre) nitrogen and not more than 20 kg/ha (18 lb/acre) nitrogen in urea form may be placed with the seed.

Do not place urea or urea-P with the seed on coarse textured soils nor with the seed on any soil under dry seedbed conditions. Place any additional fertilizer required away from the seed. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur, particularly on sandy soils or under dry soil conditions.

TABLE 15 — TRITICALE - GENERAL RATE OF NUTRIENT

Triticale to be grown on	Nitrogen $(N)_{(1)}$ kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-20	0-18	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	20-45	18-40	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	45-70	40-62	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast in the spring. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O).

(4) Low sulphur levels can occur in any Manitoba Soils. When required apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Potential Insect Pests

Grasshoppers, aphids, cutworms and armyworms are potential triticale insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Ergot Triticale is slightly more susceptible to ergot than wheat. If this is a problem, rotate with a non-susceptible crop for one year to reduce incidence (see Table 1). Cultivate fields following harvest to bury ergot bodies at least 5 cm (2 inches). Mow grass headlands and roadsides before heading to reduce spread. If the seed source contains ergot bodies, storage for more than one year reduces their viability to almost zero. Ergot body levels in the harvested grain above 0.1 per cent may be toxic in livestock feed.

Special Notes

Triticale is a new crop species still limited in its adaptation. Growers are advised to test it initially on a small scale before seeding larger acreages. Grain grades have now been established to facilitate marketing.

Triticale is more susceptible to sprouting in the swath than varieties of Hard Red Spring Wheat. Straight combining is advisable since it will minimize sprouting damage.

WHEAT

Seeding

Dates May 1 to May 31. Start seeding as early in spring as soil conditions permit. Any delay may result in lower yields.

Rates 65 to 135 kg/ha (1 to 2 bu/acre). Conditions favouring heavier rates of seeding are large seed size, low germination, late seeding, weeds, wireworms, abundant moisture, heavy textured soils, high fertility, deep seeding, and rough seedbed. Durum wheat should be seeded at the higher rate because of its large seed size.

Depth 4 to 8 cm (1.5 to 3 in). Plant seeds only deep enough to reach moisture, within the 4 to 8 cm (1.5 to 3 in) zone. Seeding deeper than 8 cm (3 in) may cause decreased emergence and weaker plants, and may result in lower yields.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 in) and 15 to 60 cm (6 to 24 inches).

For most efficient use of the fertilizer, place all phosphate, potash, and nitrogen in the seed row when possible. Total seed-placed fertilizer should not exceed 195 kg/ha (174 lb/acre). Up to 45 kg/ha (40 lb/acre) nitrogen and not more than 20 kg/ha (18 lb/acre) nitrogen in urea form, may be placed with the seed.

Urea or urea-P should not be placed with the seed on coarse textured soils nor with the seed on any soil under dry seedbed conditions. Place any additional fertilizer required away from the seed. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur particularly on sandy soils or under dry soil conditions.

TABLE 16 — WHEAT - GENERAL RATE OF NUTRIENT

Wheat to be grown on	Nitrogen (N)$_{(1)}$ kg/ha	Nitrogen (N)$_{(1)}$ lb/acre	Phosphate (P_2O_5) kg/ha	Phosphate (P_2O_5) lb/acre	Potash (K_2O) kg/ha	Potash (K_2O) lb/acre	Sulphur (S) kg/ha	Sulphur (S) lb/acre
Fallow or legume breaking (2)	0-30	0-27	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	30-60	27-54	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	60-100	54-89	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O).

(4) Low sulphur levels can occur in any Manitoba soil. When required apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Nitrogen Fertilization and Protein Content High protein Red Spring Wheat can be grown in all areas of Manitoba if sufficient nitrogen is available to the plant from the soil or from nitrogen applied as fertilizer. As the nitrogen supply is increased from low to high, an increase in yield results first, followed by an increase in both yield and protein content. Wheat protein content is about 13.2 to 13.5 per cent when sufficient nitrogen is present for near maximum yields. To determine if sufficient nitrogen is present for near maximum yields, check the grain's protein content. If protein content is less than 13.2 per cent, insufficient nitrogen has been added. When the protein content is more than 13.5 per cent, sufficient nitrogen has been added. The following table provides guidelines for the amounts of nitrogen fertilizer required to produce wheat of a particular protein content. Average values for soil-available nitrogen are used.

TABLE 17 — WHEAT — NITROGEN FERTILIZER REQUIREMENTS
kg N/ha (lb N/acre)

Wheat Grown On	"Target" Protein Content (%) for Red Spring Wheats					
	12.5		13.5		14.5	
	Area A[2]	Area B[3]	Area A	Area B	Area A	Area B
Fallow or legume breaking (1)	0(0)	0(0)	0(0)	0(0)	30(27)	10(9)
Grass and grass-legume breaking (1)	20(18)	0(0)	60(54)	30(27)	100(89)	80(71)
Stubble	60(54)	35(31)	100(89)	70(62)	140(125)	120(107)

(1) Refers to breaking after first cut of forage (before June 30).

(2) Area A refers to Zones 3, 3A, 4 and 6.

(3) Area B refers to Zones 1, 2, 2A and 5.

Nitrogen Fertilization of Semi-Dwarf Wheat

In Manitoba, maximum yields of the semi-dwarf CPS and the standard height CWRS wheat varieties are obtained at similar levels of nitrogen fertility. The semi-dwarf varieties produce, on average, 30% higher grain yields, however the grain protein content is two to three per cent lower than that of CWRS varieties. Consequently, total nitrogen requirements are the same for both types. Therefore, producers should follow current "standard" soil test fertilizer recommendations for spring wheat when growing semi-dwarf varieties. If the "target" yield recommendations are to be used, the yield of a semi-dwarf variety at a particular nitrogen level can be estimated by multiplying the value for "wheat" by a factor of 1.3. It should be noted that the semi-dwarf varieties are less prone to lodging than standard varieties under conditions of high moisture and nitrogen fertility.

Potential Insect Pests

Grasshoppers, aphids, cutworms and armyworms are potential wheat insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Loose Smut or Bunt Seed of varieties having fair resistance to loose smut or bunt should be treated with a suitable fungicide every three years. Those with poor resistance every two years. See Table 2.

Ergot If ergot has been a problem, rotate with a non-susceptible crop for one year to reduce incidence (see Table 1). Cultivate fields following harvest to bury ergot bodies to a depth of at least 5 cm (2 inches) and mow grass headlands and roadsides before heading to reduce spread. A seed source known to contain ergot bodies should be stored for more than one year to reduce viability to almost zero. Levels of ergot bodies in harvested grain above 0.1 per cent may be toxic in livestock feed.

Fusarium Head Blight (Scab) Fusarium head blight can develop in a wheat crop when infected debris is present, and preliminary observations suggest that durum and semi-dwarf wheats may be more susceptible. Experience in southern Ontario indicates that overwintered corn debris can result in most damage to the next crop. To minimize the risk of Fusarium head blight in outbreak areas, work in debris, and rotate away from wheat and corn.

Tan Spot/Septoria Leaf and Glume Blotch Tan spot and Septoria diseases are becoming more prevalent in wheat in Manitoba. The cause is a fungus which survives from one year to the next in infected wheat straw and stubble. Rotations away from wheat for at least one year are recommended to reduce disease severity; early-season outbreaks of tan spot/Septoria have been found in fields cropped to wheat the previous year. See Table 1 for information on choice of crops in a crop rotation, and see Table 3 for a list of recommended foliar fungicides for leaf disease control.

Leaf Rust Leaf rust can cause yield loss to susceptible varieties of spring wheat under conditions favorable for disease outbreaks. See Table 3 for a list of recommended foliar fungicides.

Harvesting

Experiments show that highest yields are obtained by swathing when the kernel moisture content is about 35 per cent; there is no loss in quality, test weight, or seed size. This stage is reached when the kernels are firm but easily dented by the thumb nail. Greenest kernels should show a slight colour change towards yellow or brown.

WINTER WHEAT

Management Practices

Plants must be protected from cold winter temperatures. The most effective method of protection is to use zero tillage.

Winter wheat is planted directly into the standing stubble of the previous crop. The standing stubble traps snow on the field which will then act as

an insulating blanket to prevent cold temperature killing of plants. The preceding crop must provide upright stubble and must be harvested early to allow winter wheat to be planted on time. Barley, canola (particularly Polish types), oats, flax and buckwheat stubble can be used.

Stubble Height

The stubble from a previous cereal or flax crop should be 15-20 cm (6-8 inches) high and from a previous canola or buckwheat crop at least 30 cm (12 inches), to ensure that at least 15 cm (6 inches) of snow can be maintained. Excessive fall stubble can lead to difficulties in seeding, slow growth in spring and the possibility of snow mould.

Seeding

Dates August 20 to September 15. Optimum date for southern areas of Manitoba is the first week of September, while the last week of August is best for northern areas. Winter wheat should be planted early enough to ensure that plants have 3 to 4 leaves at freeze-up. Delays in seeding cause late maturity, poor competition with weeds, increased risk of rust infection and lower yields.

Rates 70 to 100 kg/ha (63 to 89 lb/acre). Conditions requiring heavier seeding rates are low germination, late seeding, heavy textured soils, deep seeding, poor drill penetration, abundant moisture, or high fertility.

Depth 1.5 to 3 cm (0.6 to 1.2 inches). Winter wheat should be seeded shallow. Deep seeding late in the season causes a delay in emergence which may result in a poor stand.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to six in) and 15 to 60 cm (six to 24 in).

Place all potash in the seed row for most efficient use of the fertilizer. Required phosphorus should also be placed in the seed row in the fall for optimum efficiency and promotion of winter survival. Excess seed-placed phosphorus should be avoided because it can decrease winter survival. If phosphorus is banded away from the seed, it should be placed near the seed row so that it can be reached by the plant roots early in the growing season.

Between 20 and 30 kg/ha (18 to 27 lb/acre) of nitrogen can be applied with the seed to encourage early growth if soils are very low in nitrogen. The nitrogen source applied with the seed should not be anhydrous or aqua ammonia. Not more than 20 kg/ha (18 lb/acre) nitrogen in the urea form may be placed with the seed. Total seed-placed fertilizer should not exceed 195 kg/ha (174 lb/acre). Additional nitrogen can be banded away from the seed before planting, however high rates of nitrogen in the fall may decrease winter survival of the stand. Preplant banding may also lead to seedbed damage, reduce seedling establishment, and reduce the

amount of snow trapping which may reduce stand survival. Additional nitrogen may be more safely applied as a broadcast application in spring.

Ammonium nitrate (34-0-0) is a better nitrogen source than urea (46-0-0) when applications are broadcast in the spring without incorporation. Losses of urea tend to be higher than those of ammonium nitrate under adverse conditions. High temperatures and high soil pH increases the risk of urea loss. Losses of urea can be minimized by applying to moist, but not saturated soil surfaces, during periods of low temperature, immediately prior to rainfall.

TABLE 18 — WINTER WHEAT - GENERAL RATE OF NUTRIENT

Wheat to be grown on	Nitrogen (N)(1) kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Stubble	60-100	54-89	30-45	27-40	(2)	(2)	(3)	(3)

(1) Rates are based on granular nitrogen applied broadcast in the spring.

(2) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O).

(3) Low sulphur levels can occur in any Manitoba soil. When required, apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulpher fertilizer, see page 25.

Potential Insect Pests

Grasshoppers, aphids, cutworms and armyworms are potential winter wheat insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Follow a crop rotation of at least one year between wheat crops. Avoid other cereal crops in the rotation to control soil borne diseases.

Rust All varieties of winter wheat are susceptible to stem and leaf rust. In some years, severe losses may occur due to rust infection. Losses as high as 40% have been recorded in Manitoba under severe disease conditions. See Table 3 for list of recommended foliar fungicides.

Tan Spot/Septoria and Glume Blotch Winter wheat should not be planted into wheat stubble; tan spot and Septoria may affect plants the following spring and throughout the season during periods of moist weather. See Table 1 for information on choice of crops in a crop rotation. See Table 3 for list of recommended foliar fungicides.

Loose Smut or Bunt Seed of varieties having fair resistance to loose smut or bunt should be treated with a suitable fungicide every three years. Those with poor resistance every two years. See Table 2.

OILSEEDS AND SPECIAL CROPS

BUCKWHEAT

Seeding

Date June 1 to June 25. Buckwheat is susceptible to late spring and early fall frosts which can cause significant yield reductions. To obtain maximum yields, especially of Mancan, plant before June 10. Northern plantings should be no later than June 15 to avoid early fall frosts.

Rate 40 to 55 kg/ha (.75 to 1 bu/acre)

Depth 4 to 6 cm (1.5 to 2.5 in)

Fertilizer

For specific recommendations, have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

Any nitrogen in excess of seven kg/ha (six lb/acre), phosphate in excess of 20 kg/ha (18 lb/acre) P_2O_5 and all potash and sulphur should be placed away from the seed to avoid seed injury. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur particularly on sandy soils or under dry soil conditions.

TABLE 19 — BUCKWHEAT - GENERAL RATE OF NUTRIENT

Buckwheat to be grown on	Nitrogen (N)(1) kg/ha	Nitrogen (N)(1) lb/acre	Phosphate (P_2O_5) kg/ha	Phosphate (P_2O_5) lb/acre	Potash (K_2O) kg/ha	Potash (K_2O) lb/acre	Sulphur (S) kg/ha	Sulphur (S) lb/acre
Fallow or legume breaking (2)	0-20	0-18	(3)	(3)	(4)	(4)	(5)	(5)
Grass and grass-legume breaking (2)	20-45	18-40	(3)	(3)	(4)	(4)	(5)	(5)
Stubble	45-70	40-62	(3)	(3)	(4)	(4)	(5)	(5)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) 30 to 45 kg/ha (27 to 40 lb/acre) of P_2O_5 about 2.5 cm (1 inch) to the side and 2.5 cm (1 inch) below the seed is recommended. No more than 20 kg/ha (18 lb/acre) should be placed with the seed.

(4) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) of potash (K_2O).

(5) Low sulphur levels can occur in any Manitoba soil. When required apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Insect Control

Grasshoppers and cutworms are potential buckwheat insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Harvesting

Early swathing can seriously reduce yields. Swath buckwheat when about 75 per cent of the seeds have turned brown. In order to minimize shattering, swath under dewy conditions. In the event of light frost, leave until the normal per cent of seeds have turned brown. If severe frost occurs and stems are frozen, swath promptly to reduce loss from shattering. When combining, a cylinder speed of 600 to 800 revolutions per minute may be used as an initial setting. Seed is considered dry at 16 per cent moisture content.

Special Notes

Buckwheat is a naturally cross-pollinated crop with insects being the main pollinating agents. Increases in yield are usually achieved by establishing colonies of bees near fields of buckwheat.

CANARYSEED

Canaryseed is an annual grass requiring about the same time to mature as wheat. Early May planting is recommended for maximum yield. A seeding rate of 40 kg/ha (35 lb/acre) is recommended, at a planting depth of 3.5 to 5 cm (1.5 to 2 inches).

Canaryseed fertility needs can be determined by soil testing. If soil analyses are not available, the higher rates recommended for cereal crops may be used.

Canaryseed is resistant to shattering and may be direct combined or swathed when fully mature. A maximum of 12 per cent moisture is considered safe for storage (use flax chart in moisture determination). Additional information may be obtained from the Manitoba Agriculture publication 'Canary Grass Seed Production in Manitoba', and from contracting agencies.

Insect Control

Grasshoppers, aphids, cutworms and armyworms are all potential canaryseed insect pests. See Table 4 on page 20 for cultural control and threshold level information. Aphids are sometimes found in large numbers on canaryseed. However, threshold levels have not yet been determined.

CANOLA/RAPESEED

Seeding

Dates Argentine type — May 5 to May 30
Polish type — May 5 to June 15

Canola should be sown early for uniform ripening, better grade and higher yield. The Argentine type varieties are later maturing and represent a greater risk if grown in areas with a short frost free season. The Polish type varieties are lower yielding but mature earlier and are less likely to sustain frost damage in short-season areas or if seeding is delayed.

Rates Argentine type — 6 to 8 kg/ha (5 to 7 lb/acre)
Polish type — 5 to 7 kg/ha (4 to 6 lb/acre)

Depth 2.5 to 4 cm (1 to 1.5 inches)

Fertilizer

For specific recommendations have your soil tested. Take samples at depths 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

Any nitrogen in excess of seven kg/ha (six lb/acre), phosphate in excess of 20 kg/ha (18 lb/acre) P_2O_5 and all potash and sulphur should be placed away from the seed to avoid seed injury. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur, particularly on sandy soils or under dry soil conditions.

TABLE 20 — CANOLA/RAPESEED - GENERAL RATE OF NUTRIENT

Canola/ Rapeseed to be grown on	Nitrogen $(N)_{(1)}$ kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-35	0-31	(3)	(3)	(4)	(4)	(5)	(5)
Grass and grass-legume breaking (2)	35-80	31-71	(3)	(3)	(4)	(4)	(5)	(5)
Stubble	80-100	71-89	(3)	(3)	(4)	(4)	(5)	(5)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) 30 to 45 kg/ha (27 to 40 lb/acre) of P_2O_5 as a sideband application about 2.5 cm (1 inch) to the side and 2.5 cm (1 inch) below the seed is recommended. No more than 20 kg/ha (18 lb/acre) should be placed with the seed.

(4) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) of potash (K_2O).

(5) Twenty kg/ha (18 lb/acre) of sulphate sulphur (S) are recommended on well drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer see page 25.

Disease Control

Use seed from disease-free fields. Treat seed to control seed rot, seedling blights, and to prevent the introduction and establishment of blackleg into blackleg free areas. (See Table 2) Where blackleg is already established in an area, seed treatments are ineffective in controlling the disease. Do not sow canola or rapeseed adjacent to canola or rapeseed stubble. To control blackleg and soil borne diseases, follow a crop rotation of at least four years and control volunteer plants, wild mustard and other cruciferous weeds between canola crops. Avoid fababeans, field beans, field peas, forage legumes, lentils, mustard, safflower, soybeans and sunflowers in the rotation because of sclerotinia stem rot. See Table 3 for list of recommended foliar fungicides.

Insect Control

Grasshoppers, cutworms, bertha armyworms, flea beetles and diamondback moths are all potential canola insect pests.

Flea beetles can damage canola crops from early seedling stage to harvest. Seed treatments are strongly recommended. Observations throughout the entire growing season are necessary to determine if post-emergence sprays are needed.

For recommended insecticides see Table 2. Additional information can be found in the Manitoba Agricultural 'Insect Control Guide'.

Desiccation

Desiccation may be used to chemically accelerate plant drying. It does not speed crop maturity but will reduce the time from maturity to harvest. The 'Manitoba Guide to Chemical Weed Control' contains specific recommendations.

Harvesting

Canola should be swathed when the seeds contain about 30 to 35% moisture, or when 30 to 40% of the seeds in pods on the main stem have started to change or have changed color. Swathing at this stage minimizes the number of immature or green seeds, the major grade loss factor in Canadian canola or rapeseed. Green, immature seeds can lead to green color in the oil (high chlorophyll content). The problem of high levels of green seed occurs almost exclusively with the *B. napus* cultivars, which are later maturing than the *B. campestris*. Chlorophyll levels decrease as seed moisture levels decrease and the seed approaches maturity. Harvesting methods which allow slow ripening are beneficial in decreasing the number of green seeds. Weather conditions following swathing, particularly drought or frost, contribute to the condition of the seed. Very hot or dry weather may dry up stems before moisture and nutrients have a

chance to move into the seed. Early frosts which halt seed development also contribute to the green seed problem. An early seeding date combined with a high seeding rate is recommended to allow even ripening and swathing during the optimum period between August 16th and August 31st.

Storage

Safe storage of canola (rapeseed) requires considerable care and attention. Spoilage can occur very quickly, so frequent checking of the canola is advised. High temperatures and moisture contents are the most important factors contributing to spoilage, although broken seeds and exposure to damp weather before harvesting will also increase the likelihood of spoilage.

Placing canola in small wooden bins provides no guarantee of safe storage. If the storage bin is not equipped with an aeration system, the moisture content should be 8.5% or lower. If the canola temperature is above 25°C when placed into storage, the moisture content should be below 8%. In storages equipped with aeration systems, canola can be stored safely at 9% moisture, if the temperature is reduced as soon as outside air conditions permit. Winter storage temperatures should be +5°C or lower.

FABABEANS

Seeding

Inoculate seed with a recommended specific fababean inoculum.

Dates April 25 to May 15. Seeding should start once soil conditions permit. Late planting results in delayed maturity and extreme frost hazard.

Rates 135 to 200 kg/ha (120 to 180 lb/acre). Large seeded varieties require the higher rates.

Depth 6 to 10 cm (2.5 to 4 in). Fababeans are slow to emerge and must be in contact with moisture until well established.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 in).

Nitrogen is not recommended. Phosphate is recommended at 30 to 45 kg/ha (27 to 40 lb/acre) P_2O_5 as a sideband application. If applied with the seed, the maximum rate of P_2O_5 recommended is 20 kg/ha (18 lb/acre). Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) potash (K_2O). Place potassium away from the seed.

Sulphate sulphur (S) at a rate of 20 kg/ha (18 lb/acre) is recommended on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer see page 25.

Insect Control

Aphids are the prime insect pests for fababeans. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Fababeans are susceptible to a number of diseases which attack other broad-leaved crops. Use of seed known to be free of Ascochyta is recommended to avoid losses from seed borne Ascochyta blight. Follow a crop rotation of at least four years between successive crops of fababeans to control Ascochyta and other soil borne diseases. Because of Sclerotinia disease, field beans, field peas, lentils, mustard, safflower, canola, rapeseed, soybeans and sunflowers should be avoided in the rotation. For further information on Sclerotinia Disease, see Introduction — Disease Control — plus Table 1.

Harvesting

Fababeans should be swathed when the lowest two pods have begun to darken. In a late year, the crop can be safely swathed slightly earlier when pods are still green. Under these conditions, earlier swathing provides additional time for dry-down.

It is advisable to lay a fairly light swath, especially in a heavy stand, since a considerable amount of moisture must be lost from the green crop. If lodging is a problem, a pick up reel may be beneficial.

When combining the crop, set the concave at maximum clearance and reduce cylinder speed to minimize seed damage. Fababeans are dry at 16% moisture content.

If fababeans are tough, natural air drying with high airflow rates is effective. If hot air drying is required, drying in two stages may be necessary to prevent stress cracking.

For additional information on harvesting and drying, see Manitoba Agriculture Factsheet 'Fababean Production'.

FIELD BEANS

Seeding

Field beans are easily damaged by spring and fall frosts, so early and late seeding should be avoided. Inoculate seed with a recommended specific field bean inoculum.

Dates: Navy Beans — May 24 to June 1
Black Beans — May 20 to May 27
Pinto Beans — May 20 to May 27

Rates: Navy Beans — 45 kg/ha (40 lb/acre)
Black Beans — 45-55 kg/ha (40-49 lb/acre)
Pinto Beans — 60-70 kg/ha (54-62 lb/acre)

Depth: 4 to 6 cm (1.5 to 2.5 inches)

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 in).

Nitrogen is not recommended for any bean crops. Phosphorus is not recommended for black beans. For other field beans apply 30 to 45 kg/ha (27 to 40 lb/acre) P_2O_5 as a sideband application. If applied with the seed, the maximum rate of P_2O_5 recommended is 20 kg/ha (18 lb/acre). Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) potash (K_2O). Place potassium away from the seed.

Sulphate sulphur (S) at a rate of 20 kg/ha (18 lbs/acre) is recommended on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer see page 25.

Desiccation

Desiccation may be used to chemically accelerate plant drying. It does not speed crop maturity but will reduce the time from maturity to harvest. Check Manitoba Agriculture's annual 'Guide to Chemical Weed Control' for specific recommendations.

Disease Control

Bacterial Blight Use pedigreed seed or seed known to be free from bacterial blight. See Table 3 for a list of recommended foliar fungicides for bacterial blight control. Chemical control may not be practical except for small seed plots or other special situations. Avoid working fields when leaves are wet.

Rust Heavy infection of rust reduces yield, particularly of pinto beans. After harvest all bean refuse should be completely turned under.

Sclerotinia Disease (white mold) Avoid fababeans, field peas, lentils, mustard, canola, rapeseed, safflower, soybeans and sunflowers in the rotation. Avoid dense foliage favorable for disease development by restricting nitrogen. Follow a crop rotation of four years to control Sclerotinia and other soil-borne diseases. See Table 3 for a list of recommended foliar fungicides, for sclerotinia control.

Special Notes

Field beans are sensitive to certain herbicide residues such as atrazine. Extreme care must be used in applying herbicides to any crop that is to precede a bean crop. A row spacing of 60 to 70 cm (24 to 28 inches) is advisable, particularly if specialized bean equipment is being used.

Harvesting

Harvesting field beans consists of three operations — pulling, windrowing, and combining. Pulling is done when most of the pods are dry and the beans have hardened. Fixed blade pullers are most commonly used. Rotary disk-type pullers have an advantage under wet soil conditions. After drying for several days, the beans are windrowed and combined. Pulling and windrowing operations should be done in the early morning when the crop is tough to prevent shattering losses. Combining should be done at moisture contents of 16 to 18%. Below 16%, cracking and splitting of the beans can become severe. Combining should be done immediately following windrowing to prevent losses from wind damage.

The major types of combine used to thresh field beans, from most to least desirable are: special edible bean combine; rotary; spike tooth; conventional rasp bar. Since considerable soil is normally taken into the combine with the bean plants, screens should be installed to sieve out this dirt.

A recent trend has been to straight combine them with a floating cutterbar. Success depends on the variety and the height of the pods from the ground. Losses are normally higher with this method, although there are advantages; less dirt is taken into the combine, the beans are less susceptible to weathering and staining problems and less equipment and fewer field operations are required.

Handling and Drying

Beans should be handled carefully to minimize damage. If possible use a belt conveyor instead of an auger. Avoid dropping from excessive heights. Mechanical damage becomes more severe at low temperatures and moisture contents.

If necessary, drying should be undertaken using unheated (ambient) air. Beans with a moisture content of up to 22% should be dried using unheated air. Further information is available from the Manitoba Agriculture publication 'Grain Aeration and Unheated Air Drying'.

FIELD PEAS

Seeding

Inoculate seed with a recommended specific field pea inoculum.

Dates: May 1 to May 25.

Rates: Large-seeded — 170-200 kg/ha (2.5 to 3 bu/acre).
Small-seeded — 130 kg/ha (2 bu/acre).

Depth: 5 to 8 cm (2 to 3 in).

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 in) and 15 to 60 cm (6 to 24 in).

Nitrogen is not recommended. Phosphorus is recommended at 30 to 45 kg/ha (27 to 40 lb/acre) P_2O_5 as a sideband application. If applied with the seed the maximum rate of P_2O_5 recommended is 20 kg/ha (18 lb/acre). Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) potash (K_2O). Place potassium away from the seed. Sulphate sulphur(S) at the rate of 20 kg/ha (18 lbs/acre) is recommended on well drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer see page 25.

Potential Insect Pests

Aphids are the only potential insect pest for field peas. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

Mycosphaerella (Ascochyta) Use of seed tested for disease is strongly recommended to avoid losses from seed borne Ascochyta. Follow a crop rotation of at least four years between successive crops of peas to control Ascochyta and other soil borne diseases. Plant peas as far as possible from pea fields of the previous year. Bury refuse and stubble after harvest and control volunteer seedlings soon after emergence.

Sclerotinia Because of Sclerotinia disease, avoid field beans, lentils, mustard, canola, rapeseed, safflower, soybeans and sunflowers in the rotation.

Powdery Mildew Damage from powdery mildew is reduced by early seeding or by planting early maturing varieties.

Insect Control

Aphids are the only potential insect pest of field peas. See Table 4, page 20 for threshold level information.

Desiccation

To chemically accelerate plant drying, desiccation may be used. It does not speed crop maturity, but will reduce the time from maturity to harvest. Refer to the Manitoba Agriculture annual 'Guide to Chemical Weed Control' for specific recommendations.

Harvesting

Peas are dry at 16% moisture. Harvesting yellow and green pea varieties tough (16.1 - 18.0%) may be advisable to reduce splitting and cracking of seed coats. Combining green peas as soon as possible also helps reduce loss of green colour (bleaching) from weathering.

If drying is required, unheated (ambient) air drying is recommended for moisture contents up to 20%. Heated air drying may be used successfully in bin driers. Temperatures should not exceed 50°C (120°F). If moisture contents are over 20%, heated air drying should be done in two stages to prevent stress cracking.

For more information on harvesting of field peas, see the Manitoba Agriculture publication 'Field Pea Production in Manitoba'.

FLAX

Seeding

Dates: Early maturing varieties — May 10 to June 10
Late maturing varieties — May 10 to May 30
These seeding dates represent a suggested maximum range. Location and climatic conditions will determine optimum seeding date.

Rates: 30 to 45 kg/ha (27 to 40 lb/acre). Actual rate used will depend upon seedbed preparation, size of seed, percentage germination, moisture reserves and weed competition.

Depth: 2.5 to 4 cm (1 to 1.5 in). Flax should not be placed deeper than necessary to assure contact with moisture. Shallow, uniform seeding is best accomplished with a press drill. Deep seeding may result in decreased emergence and weaker plants. Spring tillage before seeding should be shallow in order to maintain a firm seedbed which promotes good stands and good plant vigor. If deep tillage is necessary, packing before or after seeding may be required.

Fertilizer

For specific recommendations have your soil tested. Take samples at a depth of 0 to 15 cm (0 to 6 in) and 15 to 60 cm (6 to 24 in).

All fertilizer material should be placed away from the seed to avoid seed injury. When using anhydrous ammonia or aqua ammonia apply no less than five days before seeding.

TABLE 21 — FLAX - GENERAL RATE OF NUTRIENT

Flax to be grown on	Nitrogen $(N)_{(1)}$ kg/ha	Nitrogen $(N)_{(1)}$ lb/acre	Phosphate (P_2O_5) kg/ha	Phosphate (P_2O_5) lb/acre	Potash (K_2O) kg/ha	Potash (K_2O) lb/acre	Sulphur (S) kg/ha	Sulphur (S) lb/acre
Fallow or legume breaking (2)	0	0	(3)	(3)	(4)	(4)	(5)	(5)
Grass and grass-legume breaking (2)	0-45	0-40	(3)	(3)	(4)	(4)	(5)	(5)
Stubble	45-70	40-62	(3)	(3)	(4)	(4)	(5)	(5)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) 30 to 45 kg/ha (27 to 40 lb/acre) of P_2O_5 is recommended if it can be applied 2.5 cm (1 inch) below the seed or be sidebanded 2.5 cm (1 inch) beside and 2.5 cm (1 inch) below the seed.

(4) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) of potash (K_2O).

(5) Low sulphur levels can occur in any Manitoba soil. When required apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information regarding the application of the different forms of sulphur fertilizer refer to page 25.

Insect Control

Grasshoppers, aphids, cutworms, and bertha armyworms are potential insect pests for flax. See Table 4 on page 20 for cultural control and threshold level information.

Disease Control

For seed rot and seedling blight control, flax seed should be treated (refer to Table 2). Follow a four year crop rotation and avoid legumes, potatoes and sugar beets because of Rhizoctonia (Root Rot) (see Table 1).

The recommended varieties are resistant to rust. To reduce the threat of pasmo (fungus diseases of flax) and rust, use clean seed, control volunteer flax and plant early. Do not plant on or near flax stubble.

Harvesting

Flax may be swathed after 75 per cent of the bolls have turned brown, and later threshed with a combine when dry. Straight combining is possible if both plant and seeds are sufficiently dry. Desiccation may be used to accelerate plant drying. It does not speed crop maturity but will reduce the time from maturity to harvest. For specific recommendations, consult Manitoba Agriculture's annual 'Guide to Chemical Weed Control'. A maximum of 10.5 per cent moisture is considered safe for storage of seed.

If the seed is to be used for planting, care in threshing is required. The seed coat of flax is easily broken during threshing, particularly if the cyl-

inder speed is too high and the seed is very dry. Damaged seed has reduced germination. It may be necessary to adjust the combine from time to time during the day depending on temperature, relative humidity and the moisture content of the crop.

Special Notes

Canola residue can have an adverse effect on flax yields. Canola straw should be spread uniformly, and seeding into untilled canola stubble minimizes the problem.

LENTILS

Seeding

Inoculate seed with a specific lentil inoculum.

Dates: May 1 - 15

Rates: 35-80 kg/ha (30-72 lb/acre) Large seeded varieties require the higher rates.

Depth: 2.5-4 cm (1-1.5 in)

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

Nitrogen is not recommended. Phosphorus is recommended at 35 to 45 kg/ha (27 to 40 lb/acre) P_2O_5 as a sideband application. If applied with the seed, the maximum rate of P_2O_5 recommended is 20 kg/ha (18 lb/acre). Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) potash (K_2O). Place potassium away from the seed. Sulphate sulphur(S) at the rate of 20 kg/ha (18 lbs/acre) is recommended on well drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer see page 25.

Disease Control

Ascochyta To prevent Ascochyta blight, plant only clean, non-discolored, sound seed. If there is doubt that the seed is free from the disease, obtain an agar plate test. Turn under crop refuse soon after harvest, control volunteer seedlings and avoid planting lentils close to the previous year's field.

Sclerotinia Follow a crop rotation of four years for control of soil borne diseases and sclerotinia. Avoid fababeans, field beans, field peas, mustard, canola, rapeseed, safflower, soybeans, and sunflowers in the rotation because of Sclerotinia disease (white mold).

For further information refer to the introduction — Disease Control — plus Table 1.

Harvesting

Lentils should be swathed when plants begin to turn yellow and the lower pods are brown to brown-yellow in color. To minimize shattering, swathing should not be carried out during hot, dry periods of the day. Lentils are considered dry at 14 per cent moisture content. Combining at or below this moisture level may result in high shattering losses and damaged seed, so it is advisable to combine at a higher moisture content of 16 to 18 per cent and then dry artificially. Unheated (ambient) air drying is recommended, although heated air drying has been used successfully. Temperatures should not exceed 50°C (120°F).

For more information on Lentil production see the Manitoba Agriculture publication 'Lentil Production in Manitoba'.

MUSTARD

Seeding

Dates: May 5 to May 30

Rate: Yellow — 8 to 11 kg/ha (7 to 10 lb/acre)
Brown and Oriental — 4.5 to 7 kg/ha (4 to 6 lb/acre)

Depth: 2.5 to 5 cm (1 to 2 inches)

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

Nitrogen in excess of seven kg/ha (six lb/acre), and phosphate in excess of 20 kg/ha (18 lb/acre) P_2O_5 and all potash and sulphur should be placed away from the seed to avoid seed injury. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur particularly on sandy soils or under soil conditions.

TABLE 22 — MUSTARD - GENERAL RATE OF NUTRIENT

Mustard to be grown on	Nitrogen (N)(1)		Phosphate (P_2O_5)		Potash (K_2O)		Sulphur (S)	
	kg/ha	lb/acre	kg/ha	lb/acre	kg/ha	lb/acre	kg/ha	lb/acre
Fallow or legume breaking (2)	0-35	0-31	(3)	(3)	(4)	(4)	(5)	(5)
Grass and grass-legume breaking (2)	35-80	31-71	(3)	(3)	(4)	(4)	(5)	(5)
Stubble	80-100	71-89	(3)	(3)	(4)	(4)	(5)	(5)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) 30 to 45 kg/ha (27 to 40 lb/acre) of P_2O_5 as a sideband application about 2.5 cm (1 inch) to the side and 2.5 cm (1 inch) below the seed is recommended. No more than 20 kg/ha (18 lb/acre) should be placed with the seed.

(4) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) of potash (K_2O).

(5) Twenty kg/ha (18 lb/acre) of sulphate sulphur (S) are recommended on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information regarding the application of the different forms of sulphur fertilizer refer to page 25.

Disease Control

Treat seed to control seed rot and seedling blights.

Because of Sclerotinia disease (stem blight), fababeans, field beans, field peas, lentils, canola, safflower, rapeseed, soybeans and sunflowers should be avoided in the rotation. For further information, see the Introduction — Disease Control — plus Table 1.

Insect Control

Grasshoppers, cutworms, bertha armyworms, flea beetles, and diamondback moths are all potential insect pests for mustard.

Desiccation

Desiccation may be used to chemically accelerate plant drying. It does not speed crop maturity but will reduce the time from maturity to harvest. Refer to Manitoba Agriculture's 'Guide to Chemical Weed Control' for specific recommendations.

Harvesting

Yellow mustard is resistant to shattering but the pods tend to break off under windy conditions. Harvest when pods are fully mature.

Brown and Oriental mustard are less resistant to shattering and are usually swathed. Since green seeds will reduce the grade, leave the crop standing as long as possible.

Swathing should commence when the ripest pods show signs of shattering. At this stage 75 per cent of the seeds may have reached their mature colour (yellow or brown). In order to minimize shattering, swath under dewy conditions.

Storage

Same as for canola-rapeseed. See page 54.

POTATOES

Seed Quality and Handling

Use foundation or certified seed. Non-certified seed may contain latent viruses, bacterial ring rot and blackleg, which reduce yield. Tubers up to 80 g (3 ounces) should be planted whole. Cut larger tubers into blocky seed pieces 40 to 55 g (1.5 to 2 ounces) in size. Chips and slivers weighing less than 28 g (1 ounce) should be discarded. To reduce the risk of seed piece decay and reduced stands use these fungicidal treatments: thiophanate-methyl (Easout), metiram (Polyram), captan or mancozeb.

For rapid emergence, particularly with late maturing varieties, plant seed in warm moist soil.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

All fertilizer should be added as a sideband application 5 cm (2 inches) beside and below the seed at time of seeding for the most efficient use of the fertilizer. No more than 90 kg/ha (80 lb/acre) nitrogen in urea form should be applied as a sideband application at time of seeding. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur particularly on sandy soils or under dry soil conditions.

TABLE 23 — POTATOES - GENERAL RATE OF NUTRIENT

Potatoes to be grown on	Nitrogen (N)(1) kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	35-30	31-45	50-60	45-54	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	50-74	45-62	50-60	45-54	(3)	(3)	(4)	(4)
Stubble	70-100	62-89	50-60	45-54	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 50 to 90 kg/ha (45 to 80 lb/acre) of potash (K_2O). If the potassium fertilizer is broadcast applied the rate should be doubled.

(4) Twenty kg/ha (18 lb/acre) of sulphate sulphur (S) is recommended on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information regarding the application of the different forms of sulphur fertilizer refer to page 25.

Excess nutrient levels may occur when high rates of fertilizer are used. This can result in decreased quality and poorer storage characteristics. Soil testing to a depth of 60 cm (24 inches) is strongly recommended to monitor nutrient levels and producers should avoid applying fertilizers at rates in excess of those recommended by a soil test.

Disease Control

Follow a crop rotation of four years to control soil-borne diseases. Avoid alfalfa, flax, canola, rapeseed, sugar beets, sunflowers and sweet clover in the rotation (see Table 1). Control volunteer plants which may be sources of virus diseases and late blight.

Bacterial Ring Rot and Blackleg Equipment and storage areas should be sanitized regularly to reduce the spread of bacterial ring rot and blackleg. Use steam or a high pressure washer to clean the surface of equipment and follow with a suitable disinfectant such as Formaldehyde (dil. 1:8), Phenol (Kem-Germ), quarternary ammonium (Hy-X, Potato Gard, or Teramine), sodium hypochlorite (household bleach, dil 1:2). Dispose of cull tubers to eliminate possible sources of bacterial diseases.

Blight Early blight and late blight can be controlled by fungicidal sprays. See Table 3 for a list of recommended foliar fungicides for blight control.

Storage Diseases For control of silverscurf and fusarium dry rot treat tubers with the fungicide thiabendazole (Mertect) as they are being put into storage. Potatoes destined for export should not be treated at the Canadian rate of thiabendazole (Mertect).

Additional information is available in the Manitoba Agriculture 'Vegetable Crop Production Guide'.

Potential Insect Pests

Colorado potato beetles, and potato leafhoppers are potential insect pests. See Table 4 on page 20 for cultural control and threshold level information.

Sprout Inhibition

Potatoes can be chemically sprout inhibited by field treatment using maleic hydrazide (Royal MH 60SG). Contract application of C.I.P.C. (Sprout Nip) is necessary to control sprout growth on potatoes in storage because of storage requirements, short dormancy period, or long term storage.

Vine Killing

Use of one of several desiccants will kill top growth, assist in stopping growth of tubers and induce maturity for harvest. Recommendations are included in Manitoba Agriculture's 'Guide to Chemical Weed Control'.

Storage

Potatoes require specialized storage to prevent frost injury and temperature fluctuation and also to provide air circulation and a high relative humidity. Acceptable table stock quality can be retained until late spring

by maintaining a temperature of 4°C with a relative humidity of 90 per cent. Potatoes produced for processing require different storage temperatures. For specific recommendations, consult your processing company representative.

Mechanical Damage

The greatest single loss of tubers of marketable size and type stems from mechanical damage. Growers must exercise great care throughout the production, harvest, storage, and delivery periods to handle tubers carefully and reduce the loss resulting from mechanical injury. Careful management and attention will pay off.

NOTE: Additional information on potato practises and recommendations is available in Manitoba Agriculture's 'Vegetable Crop Production Guide'. Growers producing potatoes for processing firms under contract should note and follow the company's requirements in using chemicals for crop production.

SAFFLOWER

Safflower is again being commercially produced in Manitoba. This thistle-like plant grows 40 to 75 cm (16 to 30 inches) in height, is tolerant of high temperatures and relatively resistant to drought. It is adapted to well-drained, fertile soils. Safflower must be planted early since the growing season is approximately 107 to 156 days. Seedlings are frost hardy.

Since safflower will not compete with weeds, this crop must be grown on clean land. To date no chemicals have been registered for use with this crop. Safflower must not follow safflower in rotation due to its susceptibility to Alternaria blight. Because of Sclerotinia disease, fababeans, field beans, field peas, lentils, mustard, canola, rapeseed, soybeans and sunflowers should be avoided in rotation. To avoid disease problems, safflower should be grown in the dry areas of southwestern Manitoba. Since research is limited and safflower is prone to diseases, it should be considered a risk crop and grown only under contract. Additional information can be obtained from a contracting agency.

SOYBEANS

Seeding

Inoculate seed with a recommended specific soybean inoculum.

Date: May 15 to May 25

Rate: 130 kg/ha (116 lb/acre)

Depth: Clay — Clay loam 2 to 3 cm (.75 to 1.2 in)
Loam — Sandy loam 2 to 4 cm (.75 to 1.5 in)

Soybeans are sensitive to certain herbicide residues such as atrazine. Take extreme care in applying herbicides to any crop that is to precede

a soybean crop. A row spacing of 50 cm (20 inches) is recommended. Narrow rows are advisable when using a grain drill. Seeding with a grain drill appears to be the most practical method, but care must be taken in calibration.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

Nitrogen is not recommended. Phosphorous is recommended at 30 to 45 kg/ha (27 to 40 lb/acre) P_2O_5 as a sideband application or as an application 2.5 cm (1 inch) directly below the seed. If applied with the seed the maximum rate of P_2O_5 recommended is 20 kg/ha (18 lb/acre). Sands, sandy loam, and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) potash (K_2O). Potassium should be placed away from the seed.

Sulphate sulphur (S) at a rate of 20 kg/ha (18 lbs/acre) is recommended on well-drained soils and grey luvisol (grey wooded) soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer, see page 25.

Disease Control

Follow a crop rotation of four years to control soil-borne diseases (see Table 1). Avoid fababeans, field beans, field peas, lentils, mustard, canola, rapeseed and sunflowers in the rotation because of Sclerotinia disease. For control of seedling rot, seedling blights, and seed maggots, apply a seed treatment as recommended in Table 2. For further information see the Introduction — Disease Control — plus Table 1.

Harvesting

Harvest soybeans when pods are dry and the soybeans are hard. Swathing and combining or straight combining may be used. A floating cutterbar attachment on the swather or combine is useful. To prevent shattering, swath the soybeans in the morning when pods are moist and tough. Careful adjustment of the cylinder speed and concave clearance is critical to minimize cracking and splitting of seeds. Soybeans are considered to be dry at 14 per cent moisture content.

SUGAR BEETS

This crop is grown under contract with Manitoba Sugar Company and seed is provided under the contract.

Sugar beets require relatively light to medium textured soils that are well drained. This allows earlier planting and easier establishment of good stands in spring, plus easier harvesting in fall.

Seeding

Dates: As early as possible, about May 1.

Rates: Space seeds 7.5 cm (3 inches) apart if beet thinning is planned (2.7 kg/ha) (2.4 lb/acre)
Space seeds 15 cm (6 inches) apart if planting to a final stand without thinning (1.3 kg/ha) (1.2 lb/acre)

Depth: 2.5 to 3.5 cm (1 to 1.4 inches) depending on seedbed conditions.

Row Spacing 56 cm (22 inches) between rows.

Fertilizer

For specific recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to six inches) and 15 to 60 cm (six to 24 inches).

Drill no more than 20 kg/ha (18 lb/acre) phosphate with the seed. Work the remaining phosphate in before planting. Any nitrogen above five kg/ha (four lb/acre) and all potash and sulphur should be applied prior to planting. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur, particularly on sandy soils or under dry soil conditions.

TABLE 24 — SUGAR BEETS - GENERAL RATE OF NUTRIENT

Beets to be grown on	Nitrogen (N)(1) kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-20	0-18	65	58	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	20-65	18-58	65	58	(3)	(3)	(4)	(4)
Stubble	65-100	58-89	65	58	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 50 to 90 kg/ha (45 to 80 lb/acre) of potash (K_2O).

(4) Twenty kg/ha (18 lb/acre) of sulphate sulphur (S) are recommended on well-drained soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer, see page 25.

Excess nutrient levels may occur when high rates of fertilizer are used and can result in decreased quality. Soil testing to a depth of 60 cm (24 inches) is strongly recommended to monitor nutrient levels, and produc-

ers should avoid applying fertilizers at rates in excess of those recommended by a soil test.

Disease Control

Follow a crop rotation of at least four years to control soil-borne diseases (see Table 1). Avoid canola, rapeseed and mustard in the crop rotation because of sugar beet cyst nematodes. All seed is treated against damping-off diseases prior to sale.

Insect Control

Sugar beet root maggot is the only potential sugar beet insect pest. See Table 4 on page 20 for cultural control and threshold level information.

NOTE: Avoid seeding sugar beets on fields previously treated with Glean.

SUNFLOWERS

Seeding

Dates: All varieties should be seeded early if possible. Seedlings are relatively frost resistant up to the four leaf stage. If late seeding is necessary, early maturing varieties should be used.
Zone 3, south of Township 15: May 1 to June 5.
All other regions: May 1 to May 15.

Rates: A final population of 40,000 to 49,000 plants/ha (16,000 to 20,000 plants/acre) is recommended for oil type cultivars and hybrids. For non-oilseed types, a population of not more than 45,000 plants/ha (18,000 plants/acre) is recommended to ensure large seeds. Consider seed size in determining the quantity of seed required for seeding. Allowance must be made for low germination, reduced emergence, and the number of harrowings anticipated. Plant population depends on distance between rows and on spacing between plants within the row. See Table 23.

Row Spacing: 40-90 cm (16-36 in) are commonly used. Small increases in oil content and seed yield can be achieved by choosing spacings at the narrower end of the range, particularly with the earlier hybrids.

TABLE 25 — SUNFLOWER SEED AND ROW SPACING

Plants/ha (acre)	Row spacing — cm (inches)				
	40(16)	46(18)	56(22)	76(30)	91(36)
	Average seed spacing within row — cm (inches)				
40,000 (16,000)	58(23)	50(20)	41(16)	30(12)	25(10)
45,000 (18,000)	51(20)	44(17)	36(14)	26(10)	22(9)
49,000 (20,000)	46(18)	40(16)	33(13)	24(9)	29(8)

Stands may be reduced by harrowing. The frequency and severity of harrowing will determine the per cent stand reduction, and seeding rate is increased accordingly.

Sunflower seed is sold in different sizes. The approximate number of seeds for the different sizes are:

TABLE 26 — SUNFLOWER SEED SIZE AND WEIGHT

Seed Size	Seeds/kg	(Seeds/lb)
No. 2	11,000 - 13,200	(5,000 - 6,000)
No. 3	13,200 - 15,400	(6,000 - 7,000)
No. 4	15,400 - 19,800	(7,000 - 9,000)
No. 5	19,800 - 24,200	(9,000 - 11,000)

Depth: Seed should be placed into moisture even if this means seeding to 8 to 10 cm (3 to 4 inches).

Fertilizer

For specific target yield recommendations have your soil tested. Take samples at depths of 0 to 15 cm (0 to 6 inches) and 15 to 60 cm (6 to 24 inches).

Germinating sunflower seeds are sensitive to moderate amounts of fertilizer placed with the seed.

Row Equipment When sunflowers are seeded with row equipment, all phosphate and potash should be side-banded five cm (two inches) beside and below the seed at seeding time. Some or all of the nitrogen may also be side-banded. The total amount of fertilizer material side-banded should not exceed 340 kg/ha (303 lb/acre).

Discer Seeder When sunflowers are solid-seeded with a discer seeder in 30 to 60 cm (12 to 24 inches) row spacing, up to 25 kg/ha (22 lb/acre) P_2O_5 can be applied provided all fertilizer runs are left operating. If all phosphate must be placed with the seed, the amount of phosphate should not exceed 15 kg/ha (13 lbs/acre) P_2O_5 for 30 cm (12 inches) row spacing, 10 kg/ha (nine lb/acre) P_2O_5 for 45 cm (18 inches) row spacing and five kg/ha (four lb/acre) P_2O_5 for 60 cm (24 inches) row spacing.

Nitrogen requirements not side-banded should be placed away from the seed as a band or broadcast application. When the crop is seeded less than five days after the application of anhydrous ammonia or aqua ammonia, damage may occur particularly on sandy soils or under dry soil conditions.

TABLE 27 — SUNFLOWERS - GENERAL RATE OF NUTRIENT

Sunflowers to be grown on	Nitrogen (N)(1) kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-30	0-27	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	30-60	27-54	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	60-100	54-89	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 15 to 35 kg/ha (13 to 31 lb/acre) of potash (K_2O). If the potassium fertilizer is broadcast applied the rate should at least be doubled.

(4) Twenty kg/ha (18 lb/acre) of sulphate sulphur (S) is recommended on well-drained soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer, see page 25.

Weed Control

Cultural Methods Cross harrowing (after planting, before and after emergence of the sunflowers) with early inter-row cultivation, will usually give satisfactory control of most weeds.

Disease Control

Sclerotinia wilt or basal stem rot, Verticillium wilt, rust and downy mildew are serious sunflower diseases.

No cultivar is resistant to Sclerotinia disease. Sclerotinia wilt spreads by root contact, and the denser the plants, the greater its incidence and severity. Do not exceed the recommended seeding rates, and space plants uniformly. Plant to plant spread of the disease is reduced at spacings of 30 cm (12 inches) and greater, and is prevented at 40 cm (16 inches). Use well cleaned seed free of sclerotia (black, hard fungal bodies).

Follow a crop rotation of at least five years to control soil-borne diseases in general. Avoid fababeans, field beans, field peas, lentils, mustard, canola, rapeseed, safflower and soybeans in the rotation to control Sclerotinia disease. The organisms that cause Verticillium wilt and downy mildew survive in soil for many years, and are best controlled by planting resistant varieties. For further control of Verticillium wilt, avoid alfalfa, potato and sweet clover in the rotation. To reduce the incidence of rust use resistant varieties, control volunteer plants and do not sow sunflowers adjacent to sunflower stubble. To reduce the incidence of downy mildew, avoid planting in poorly drained fields. For further information see the Introduction — Disease Control — plus Table 1.

Insect Control

Cutworms, and sunflower beetles are potential insect pests for sunflowers. See Table 4 on page 20 for cultural control and threshold level information.

Harvesting

The period between maturity and harvest should be kept as short as possible to keep losses due to bird damage and/or head rot diseases to a minimum. Rather than waiting for a frost, a desiccant may be used to accelerate drying of sunflower plants. For details, see Manitoba Agriculture's 'Guide to Chemical Weed Control'.

Sunflower seed can be stored with a moisture level of 10 per cent or less. A moisture level of 8.5 per cent or less is more desirable, but even at this level spoilage can occur if the temperature is not reduced at the time the seed is put into storage.

WILD RICE

Wild rice may be produced in paddies containing 15 to 45 cm (6 to 18 inches) or more of water. Seeding at a rate of 35 kg/ha (30 lb/acre) can be done by broadcasting into water or onto wet ground which is then flooded either in the fall or spring. Fall seeding is an advantage since the problems of seed storage are avoided. Paddies may be harvested with float mounted equipment or drained and harvested with a combine equipped with extended tracks and a rice header.

Shallow peat or mineral soils in the natural wild rice area are used for wild rice production. Soil conditions that permit maintenance of adequate water levels in the paddies are essential.

The quantity of water available should be carefully assessed. A licence must be obtained before paddy construction.

Initial dike construction should facilitate patrol, maintenance and sanitation. Control of plant growth on dikes assists in weed and disease control in the paddies.

Weed Control

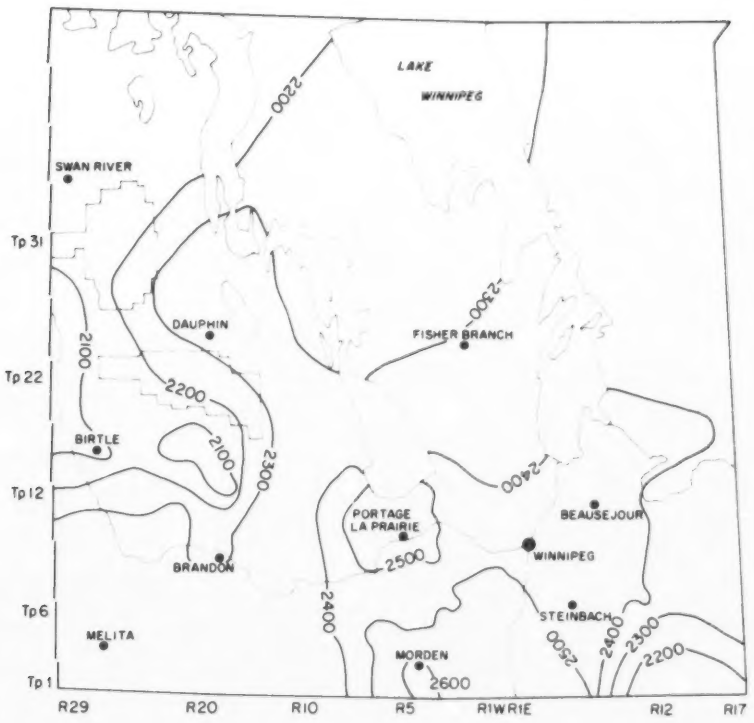
Major problem weeds include cattails, burr weed and duck weed. Some control can be achieved through water level management and fall tillage.

Disease, Insect and Variety Notes

Leaf spot disease may cause loss. Wild rice worm consumes the grain from pollination onwards. Native wild rice shatters readily and ripens unevenly although some recently developed varieties provide a degree of shatter resistance with acceptable maturity characteristics. For further information see the Manitoba Agriculture factsheet 'Wild Rice Production in Manitoba' and the 'Guide to Wild Rice Production' booklet.

CORN

FIGURE 4 — CORN HEAT UNIT MAP FOR MANITOBA



Corn Heat Units

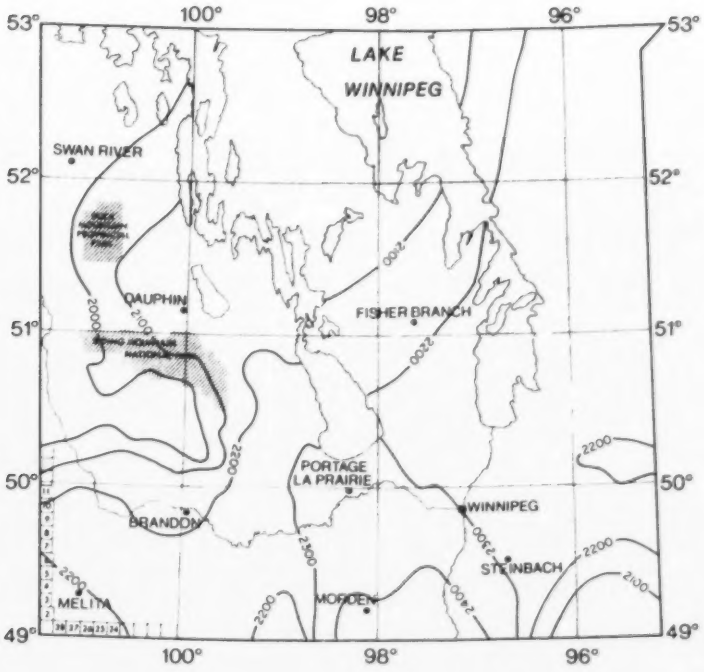
The corn production potential of an area is determined primarily by the corn heat unit accumulation. These units are calculated each day from May 15 to the date of the first frost at −2°C in the fall. Daily accumulations are summed to give a seasonal total. The map above is an average seasonal accumulation.

How to Use The Map

If you plan to grow corn for grain, find your farm location on the map and observe the heat units available. When planting in early May, choose hybrids with a heat unit rating no greater than that available on your farm. If, for any reason, planting is delayed until after mid-May, deduct 100 heat units from the rating for your farm for each week of delay and select hybrids accordingly.

For silage corn the heat unit requirement is 200 lower than for grain corn, since silage is harvested before full maturity. Hybrids requiring 200 heat units more than the rating for an area can be used in silage production, e.g. a 2,400 heat unit hybrid may be used in a 2,200 heat unit area.

FIGURE 5 — MINIMUM ACCUMULATION OF CORN HEAT UNITS AT A 25% RISK

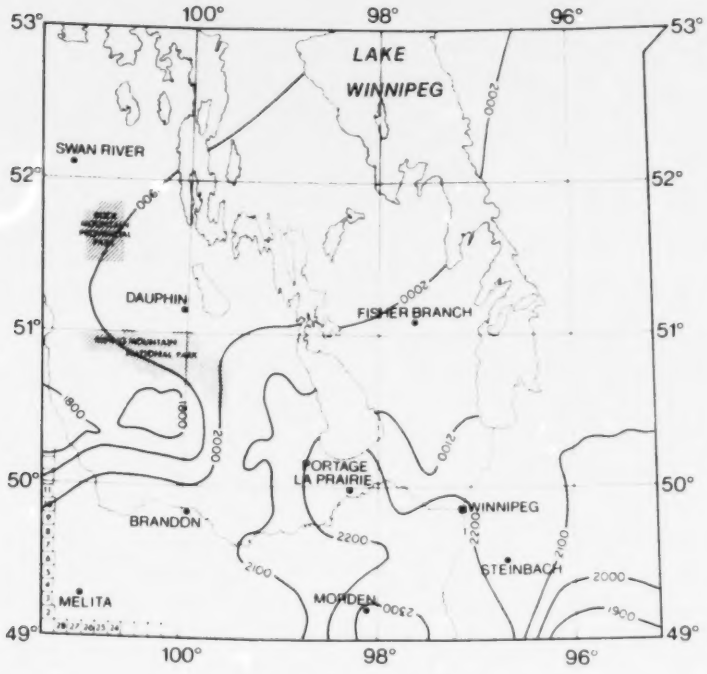


Reducing The Risk In Corn Production

The corn heat unit map shown in Figure 3 is the average corn heat unit accumulation, i.e. the map is a 50% risk map. If you chose a hybrid with the same heat unit rating as your farm, 50% of the years it would not reach maturity.

Let us assume you want to reduce your risk to 25%, i.e. you are prepared to have immature corn one year in four. In this case instead of using the average corn heat unit map (Figure 3), you would use the 25% risk map (Figure 4) in choosing your hybrid. Similarly, if you wish to reduce your risk to 10%, you would use the 10% risk map (Figure 5) in choosing your hybrid.

FIGURE 6 — MINIMUM ACCUMULATION OF CORN HEAT UNITS AT A 10% RISK



Management Practices

Successful corn production requires intensive management. New growers should consult their nearest agronomist for detailed advice on the proper techniques and materials for planting, fertilizing, spraying, harvesting, storage, etc. Obtain a copy of the Manitoba Agriculture publication 'Field Corn in Manitoba'. Corn crops properly managed in all aspects of production hold good potential for high yields. However, improper management of any one aspect of production may lead to poor results — unlike cereals in which average management usually leads to average yield. Basic recommended practices are:

Soil Requirements Corn is best adapted to well-drained, light to medium sandy loam soils. These soils usually permit early May planting, which is essential for optimum yields of good quality grain. Corn should not be grown on soils that are either poorly drained or saline (showing a conductivity reading above one millisiemen by soil test).

Seeding

Dates: May 1 to May 15. Later planting results in lower yields and quality. Planting later than May 25 for grain and June 5 for silage is not recommended.

Depth: Plant into moist soil. Under normal soil moisture conditions the suggested depth is 2.5 to 5 cm (1 to 2 in). Very dry soil conditions may require deeper planting. Check planting depth frequently to ensure uniform and early emergence.

Row Spacing: 75 to 100 cm (30 to 40 in) depending on planting and harvesting equipment.

Rates: Hybrid corn is sold in many sizes. Growers using platetype planters must use the correct plate for each seed size to obtain the desired plant population.
Grain corn — 45,000 to 60,000 plants/ha (18,000 to 24,000 plants/acre)
Silage corn — 55,000 to 70,000 plants/ha (22,000 to 28,000 plants/acre)

The lower plant populations are recommended for areas in which moisture is a limiting factor. Similarly, plant population should be reduced if planting is delayed beyond the recommended dates. Plant population depends on seed spacing within the row and on spacing between rows. See following Table.

TABLE 28 — CORN - SEED SPACING NECESSARY TO GIVE THE REQUIRED PLANT POPULATION

Assuming an 85% Plant Survival

Row Width cm(in)	Plants per ha(acre) 45,000 (18,000) cm(in)	Plants per ha(acre) 49,000 (20,000) cm(in)	Plants per ha(acre) 55,000 (22,000) cm(in)	Plants per ha(acre) 60,000 (24,000) cm(in)	Plants per ha(acre) 69,000 (28,000) cm(in)
76(30)	25(9.9)	23(8.9)	20(8.1)	19(7.4)	16(6.3)
91(36)	21(8.2)	19(7.4)	17(6.7)	16(6.2)	14(5.3)
97(38)	20(7.8)	18(7.0)	16(6.4)	15(5.8)	13(5.0)
102(40)	19(7.4)	17(6.7)	15(6.1)	14(5.6)	12(4.8)

Fertilizer

For specific target yield recommendations have your soil tested. Samples should be taken at depths of 0 to 15 cm (0 to 6 in) and 15 to 60 cm (6 to 24 in).

Phosphate, potash and nitrogen when possible should be banded 5 cm (2 in) beside and below the seed row at time of seeding. The total amount of fertilizer material side-banded should not exceed 340 kg/ha (303 lb/acre). Nitrogen requirements not side-banded at time of seeding should be side-dressed before the corn is 15 cm (6 inches) high.

TABLE 29 — CORN - GENERAL RATE OF NUTRIENT

Corn to be grown on	Nitrogen (N)(1) kg/ha	lb/acre	Phosphate (P_2O_5) kg/ha	lb/acre	Potash (K_2O) kg/ha	lb/acre	Sulphur (S) kg/ha	lb/acre
Fallow or legume breaking (2)	0-30	0-27	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	30-75	27-67	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	75-150	67-134	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time. See section Relative Efficiencies of Time and Method of Nitrogen Application, page 22.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 30 to 110 kg/ha (27 to 98 lb/acre) of potash (K_2O). If the potassium fertilizer is broadcast applied the rate should be doubled.

(4) Twenty kg/ha (18 lb/acre) of sulphate sulphur (S) are recommended on well-drained soils. Sulphur deficiency may occur in many other soils and in any area of the province. Because of this a soil test is recommended to establish the available sulphur status of your fields. For information on the application of different forms of sulphur fertilizer see page 25.

Excess nutrient levels may occur when high rates of fertilizer are used on continuous corn. Soil testing to a depth of 60 cm (24 inches) is strongly recommended to monitor nutrient levels and avoid over-fertilization.

To determine the possible cause of poor growth due to nutrient deficiencies, see pages 20 and 21 of the publication, 'Field Corn in Manitoba', and contact your local agronomist.

Disease Control

Stalk Rot Stalk rot is the main disease of corn, causing diseased plants to break over before harvest, resulting in severe losses. Organisms causing the disease are present in all soils. The disease usually occurs following periods of severe stress such as drought, or prolonged cool weather. For control measures, see the Manitoba Agriculture publication 'Field Corn in Manitoba'. Continuous cropping of corn can lead to a buildup of stalk rot and corn smut. Seed should be treated with a suitable fungicide to prevent introduction of head smut (see Table 2). Rotate with cereals other than wheat, or special crops, for several years before returning field to corn (see Table 1). 'The Crop Rotation Chart' published by Manitoba Agriculture contains further information on crop rotations.

Insect Control

European cornborer is the major potential insect pest for corn. See Table 4 on page 20 for cultural control and threshold level information.

Pest Control

Blackbirds can cause severe losses in corn production. Where possible, placement of corn fields close to sloughs and marshes should be avoided.

Harvesting

The grade of grain corn may be significantly influenced by harvesting procedure. Grain corn should contain 25 to 30 per cent kernel moisture before harvesting commences. Harvesting near the lower end of this moisture range causes a lower proportion of cracks and fines. If frost occurs before kernel moisture has reached 40 per cent, the crop should be harvested for silage rather than grain.

Silage corn harvesting should take place when whole plant moisture is 65 to 70 per cent; kernels are usually at the hard dough stage (well-dented or glazed).

FIGURE 7 — GRAIN CORN INSURANCE AREAS
CANADA-MANITOBA CROP INSURANCE

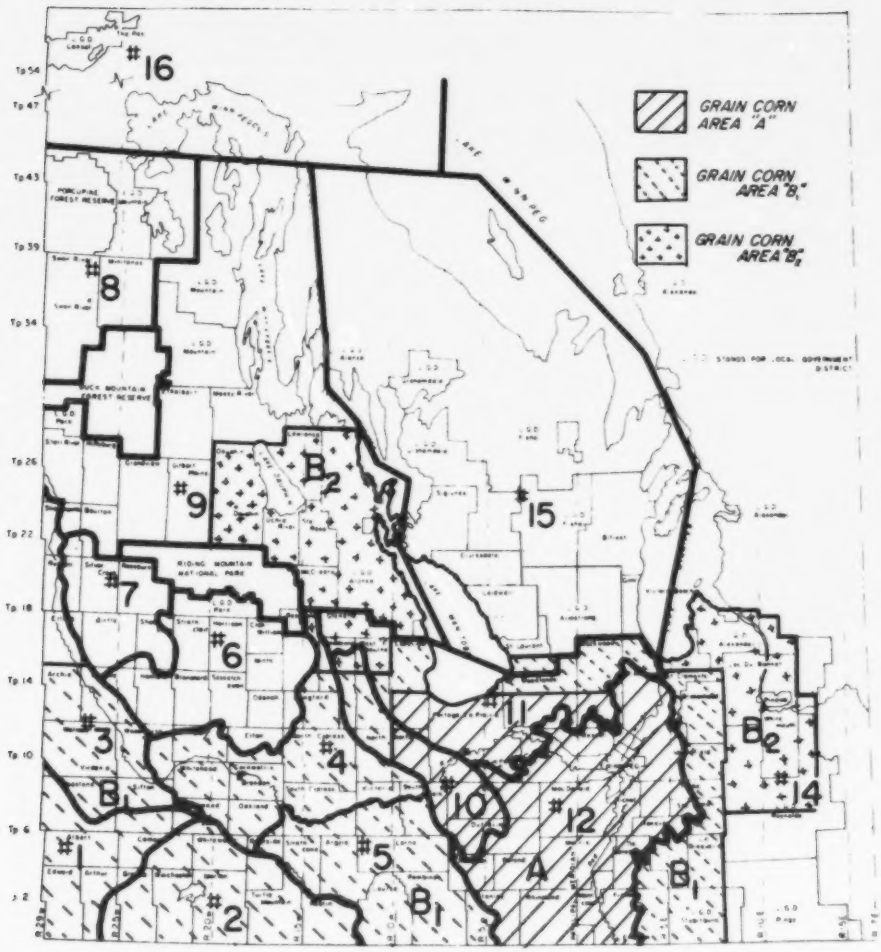
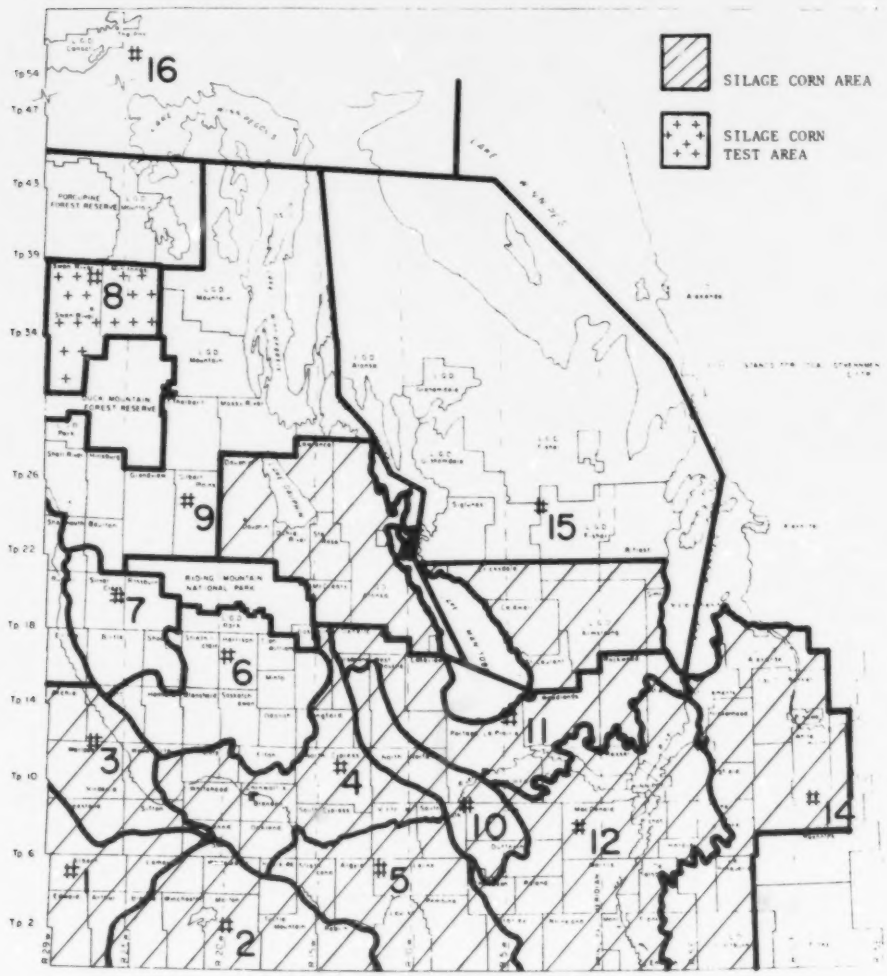


FIGURE 8 — SILAGE CORN INSURANCE AREAS
CANADA-MANITOBA CROP INSURANCE



FORAGE CROPS

TABLE 32 — RECOMMENDED GRASSES

		Seeding Rate kg/ha (lb/acre) Forage	Seed
A. All soils except where drainage is poor.			
Bromegrass	Pasture, Hay, Seed	8(7)	3(3)
Intermediate Wheatgrass	Pasture, Hay, Seed	8(7)	4(4)
Russian Wild Ryegrass	Seed		7(6)
Slender Wheatgrass	Seed		6(5)
Tall Wheatgrass	Seed		9(8)
B. Soils with ample moisture, good drainage.			
Creeping Red Fescue	Pasture	4(4)	
Meadow Fescue	Pasture, Seed	6(5)	3(3)
Orchardgrass	Pasture, Hay	7(6)	
Timothy	Pasture, Hay, Seed	2(2)	2(2)
C. Light soils and areas deficient in moisture.			
Crested Wheatgrass	Pasture, Hay, Seed	8(7)	3(3)
Russian Wild Ryegrass	Pasture	9(8)	
D. Poorly drained areas subject to temporary flooding.			
Reed Canarygrass	Pasture, Hay, Seed	7(6)	4(4)
Timothy	Pasture, Hay, Seed	2(2)	2(2)
E. Saline soils.*			
Russian Wild Ryegrass	Pasture	9(8)	
Slender Wheatgrass	Hay	9(8)	
Tall Wheatgrass	Hay	11(10)	
F. Organic soils.			
Grow winter-hardy grasses: bluegrass, bromegrass, creeping red fescue, intermediate wheatgrass, meadow foxtail, reed canarygrass, slender wheatgrass, and timothy.			

SEE GRASS ADAPTATION TABLE 30 PAGE 103.

TABLE 33 — RECOMMENDED LEGUMES

		Seeding Rate kg/ha (lb/acre) Forage	Seed
A. All soils except where drainage is poor.			
Alfalfa	Pasture, Hay, Seed	7(6)	1(1)
Sweet Clover	Hay, Seed	11(10)	7(6)
B. Soils with ample moisture, good drainage.			
Birdsfoot Trefoil	Pasture, Seed	4(4)	2(2)
Red Clover	Hay, Seed	7(6)	3(3)
C. Poorly drained areas subject to temporary flooding.			
Alsike	Hay, Seed	4(4)	2(2)
Birdsfoot Trefoil	Pasture, Seed	4(4)	2(2)
D. Saline soils.*			
Alfalfa	Hay	7(6)	
Sweet Clover	Hay	11(10)	

SEE LEGUME ADAPTATION GUIDE TABLE 31, PAGE 105.

TABLE 34 — RECOMMENDED MIXTURES	Seeding Rate kg/ha (lb/acre) Pasture	Hay
A. All soils except where drainage is poor.		
Bromegrass	7(6)	3(3)
and Alfalfa	3(3)	7(6)
Intermediate Wheatgrass	7(6)	3(3)
and Alfalfa	3(3)	7(6)
B. Soils with ample moisture, good drainage.		
Orchardgrass	7(6)	7(6)
and Timothy	2(2)	2(2)
Timothy	2(2)	2(2)
and Alfalfa	3(3)	7(6)
Orchardgrass	7(6)	3(3)
Timothy	2(2)	2(2)
and Alfalfa	2(2)	7(6)
Timothy	2(2)	
and Birdsfoot Trefoil	2(2)	
C. Light soils and areas deficient in moisture.		
Crested Wheatgrass	8(7)	5(5)
and Alfalfa	2(2)	5(5)
D. Poorly drained areas subject to temporary flooding.		
Reed Canarygrass	6(5)	
Timothy	2(2)	
and Birdsfoot Trefoil	2(2)	
Reed Canarygrass		6(5)
Timothy		2(2)
and Alsike Clover		4(4)
E. Saline soils.*		
Slender Wheatgrass		5(5)
Tall Wheatgrass		5(5)
Alfalfa		3(3)
and Sweet Clover		3(3)
F. Organic Soils.		
Bromegrass		5(5)
Timothy		2(2)
and Reed Canarygrass		5(5)

*See Agriculture Canada bulletin #1624/E — The Management of Saline Soils.

TABLE 35 — FORAGES - PLANTING GUIDE

Crop	Seeds/kg (1000s)	No. of Seeds/m of Row at 1 kg/ha Row Spacing 15 cm (6 in)	20 cm (8 in)	30 cm (12 in)
Grasses				
Kentucky Bluegrass	4 800	70	95	140
Bromegrass	300	4.5	6	9
Reed Canarygrass	1 200	18	24	35
Creeping Red Fescue	1 400	20	27	41
Meadow Fescue	500	8	10	15
Meadow Foxtail	1 300	19	25	38
Orchardgrass	1 400	22	29	43
Russian Wildrye	390	6	8	12
Timothy	2 700	41	55	80
Crested Wheatgrass	390	6	8	12
Intermediate Wheatgrass	190	3	4	6
Slender Wheatgrass	350	5	7	11
Tall Wheatgrass	170	2.5	3.5	5
Legumes				
Alfalfa	450	7	9	14
Alsike Clover	1 500	23	31	46
Red Clover	610	9	12	18
Sweet Clover	570	9	11	17
Birdsfoot Trefoil	830	12	17	25

SEEDING PRACTICES

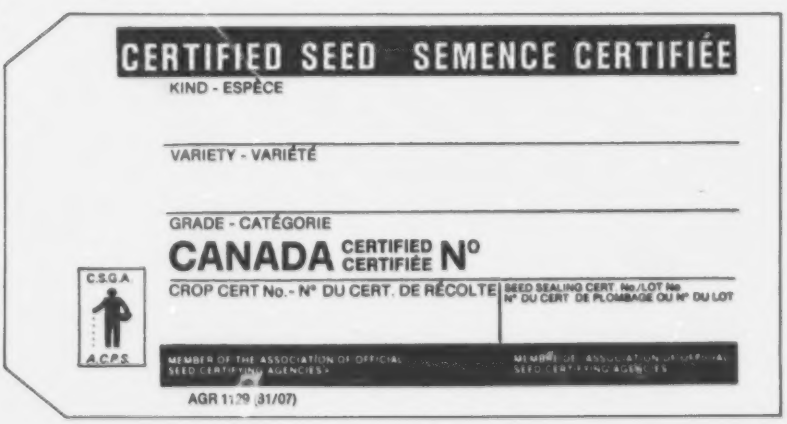
Pedigreed Seed

Whenever possible, use only pedigreed seed of the recommended varieties to be sure of a proven, high quality product that has good germination, is free from noxious weed seeds, and is adapted to your particular area. In Canada, crop seed must be pedigreed before it can be sold under a variety name. Pedigreed seed possesses the yield, winter hardiness, disease resistance, and other characteristics associated with a recommended variety.

All Pedigreed seed is identified by the type of tag shown in figure number 8. The tag has a crop certificate number and a seed certificate number. The 11-digit crop certificate number is assigned by The Canadian Seed Growers' Association, and identifies both the grower and the field that it came off.

The seed certificate number on the tag is assigned by Agriculture Canada for each lot of seed tagged by a seed inspector. There is a different number for each lot of seed. All Certified, or Pedigreed, seed is identified by the type of tag shown below.

FIGURE 9 — SAMPLE OF CERTIFIED SEED TAG


CERTIFIED SEED SEMENCE CERTIFIÉE
KIND - ESPÈCE
VARIETY - VARIÉTÉ
GRADE - CATÉGORIE
CANADA CERTIFIED CERTIFIÉE N°
C.S.G.A.
A.C.P.S.
CROP CERT No.- N° DU CERT. DE RÉCOLTE
SEED SEALING CERT. No./LOT No.
N° DU CERT. DE PLOMBAGE OU N° DU LOT
MEMBER OF THE ASSOCIATION OF OFFICIAL SEED CERTIFYING AGENCIES
AGR 1179 (81/07)

Time of Seeding

Spring — Spring seeding of forages should be done before grain is seeded. This is particularly important on light and sandy soils. In the moister areas of the province, seeding may be delayed until late May with a reasonable chance of success. Where a companion crop is being used, it is recommended that this field be the first field seeded.

Early Fall — If moisture supplies are adequate, grasses may be sown in August. While an early August seeding is preferred, seeding should be completed before the end of the third week.

Late Fall — Grasses and legumes may be seeded in late fall. If excessive soil moisture is anticipated in the spring, it is recommended that the normal seeding rates be increased by 50%. Generally grass seeds withstand excess spring soil moisture better than legume seeds.

Field Preparation

Care must be taken to ensure that the major weed problems are eliminated from the field prior to seedbed preparation. This generally requires a suitable crop rotation with chemical and cultural weed control practices prior to seedbed preparation.

The seedbed, whether summerfallow or stubble land, must be firm. A firm seedbed makes shallow seeding possible and provides better moisture conditions near the surface. Summerfallow and recently worked stubble should be packed immediately after cultivation and seeded as soon as possible. Undisturbed stubble land provides a firm seedbed for forage crops. Chemical weed spraying at seeding time may be required to reduce heavy weed competition which would otherwise occur on stubble.

Inoculation

Legume seeds require inoculation in order to ensure nitrogen fixation. This is done by coating the seed with a prepared culture of the required strain of rhizobium bacteria. Soils may contain rhizobium bacteria from a previous crop, but seed inoculation ensures nodulation. Keep inoculant in sealed original container in a refrigerator until required. This prevents drying which reduces the viability of the bacteria. Improper storage and management of inoculated seed usually results in poor nodulation and nitrogen fixation. Consequently, seeds should be planted immediately after inoculation.

Each legume or group of legumes requires a unique species of rhizobium to form nodules and fix nitrogen. The commercial inoculants available are prepared for specific legumes and groups of similar legumes.

- Alfalfa Group — for alfalfa and sweet clover
- Clover Group — for red clover, white clover, and alsike clover
- Birdsfoot Trefoil — specific to birdsfoot trefoil.

For more information on inoculation and the proper methods of applying it to the seed, please see Manitoba Agriculture factsheet entitled Legume Inoculation (120-23) and/or Agriculture Canada publication 1299 Legume Inoculation.

Companion Crops

In general, companion crops compete with the forage seedlings for moisture, nutrients and light. They reduce the number, vigor or distribution of seedlings within the forage stand. When used, the companion crop (flax, wheat, oats, barley, or rapeseed) should be planted at half the usual rate in a separate operation, preferably cross-wise or in alternate rows to the forage crop. The crop and crop residues should be removed as early as possible.

Depth of Seeding

Shallow seeding of grasses and legumes is essential to obtain satisfactory stands. Most grasses and legumes should be seeded to a maximum of 2.5 centimeters (1 inch) deep. Very small seeded crops, such as Kentucky Bluegrass, must be seeded about .5 centimeter (.25 inch) deep. For even depth shallow seeding, it is advisable to use depth control attachments on the drill discs. On firm land, shallow seeding can be accomplished with a grain drill if all pressure is taken off the discs.

The drum roller has gained popularity in establishing forage crops on newly cleared land where stones are a major limitation. Forage seed is metered from a seedbox and dropped on the soil surface in front of a large roller packer. The packer can be filled with water to pack stones and firm the soil around the forage seed. Crusting can be a problem on heavy clay soils, as can wind erosion on light soils.

Seed Distribution

Stands of grasses and legumes should be uniform, with 33 to 66 plants per square meter (3 to 6 plants per square foot). Dense stands are not necessary.

Drilling the seed into the soil is better than broadcasting, and a press-drill gives best results. Discers are not recommended because they generally sow too deeply. Most grain drills are not designed to seed forage crops in a continuous positive flow at low seeding rates. The drill settings to deliver these low seeding rates do not, in many instances, allow seed to continuously feed into the small opening. The lighted, awned, and pointed tip characteristics of most grasses results in uneven flow, bridging over the seed cup and in skips and misses in the rows. Grass seeder and depth control attachments may be obtained for the grain drill to permit more accurate rate and depth of seeding. Every precaution must be taken to avoid seeding the forage crop too deeply.

For most grasses and mixtures, start with a drill setting of 67 kilograms per hectare (1 bushel per acre) on the wheat scale, then try the drill on a hard surface. Count the number of seeds that drop per meter (foot of row) and then adjust to the setting required (refer to Table 35).

When seeding, the drill box should not be over half full or bridging may occur, causing the seed to stop flowing. Another way to prevent bridging is to mix one part cracked cereal seed with two parts of grass seed by volume. Broadcast seeding is sometimes practiced in areas of good rainfall and it may be used on rough ground or on very loose soil where the depth of seeding cannot be properly controlled. Small-seeded crops, such as alsike clover or timothy, may have to be broadcast because of the danger of seeding too deeply with a drill. Seed may be broadcast by a grain drill, with or without a fertilizer or grass-seed attachment, or by a discer. When the discer is used the grain spouts should be removed entirely. A Cyclone broadcast seeder is useful for broadcasting seed on small areas. All broadcast seeding should be followed by harrowing, and packing after harrowing is advisable.

General Management Of Grasses And Legumes

Fertilizer

For specific recommendations, have your soil tested. Take samples at depths of 0 to 15 centimeters (0 to 6 inches) and 15 to 60 centimeters (6 to 24 inches) prior to establishment or on established stands if the possibility of a sulphur deficiency has not been eliminated. Sampling to 15 centimeters (6 inches) is useful only on established stands where sulphur levels are known to be adequate.

For new forage stands, phosphorus fertilizer can be applied most effectively by banding the material 2.5 centimeters (1 inch) to the side and 2.5 centimeters (1 inch) below the seed. If phosphorus cannot be banded, incorporate it and all other fertilizer materials into the soil before seeding.

Fertilizing Grass Stands

Annual broadcast applications of phosphorus, potassium and sulphur fertilizer on established grass crops may be in late fall or early spring. Do not apply fertilizer to frozen soils subject to water runoff. Response of grasses to nitrogen fertilizers depends on the type of nitrogen fertilizer, time of application, amount applied, species of grass, age of stand, number of cuts and climatic conditions. Established grass stands should be fertilized with granular fertilizers. Nitrogen solutions sprayed onto established grass stands have been found unsatisfactory and this application technique is not recommended.

TABLE 36 — GRASSES - GENERAL RATE OF NUTRIENT

New Stands	N kg/ha	N lb/acre	P_2O_5 kg/ha	P_2O_5 lb/acre	K_2O	S
Fallow	0-20	0-18	30-45	27-45	(1)	(2)
Stubble	45-70	40-62	30-45	27-45	(1)	(2)
Established Stands	100-120	89-107	20-35	18-31	(1)	(2)

(1) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 35 to 70 kg/ha (31 to 62 lb/acre) of potash (K_2O) for established stands and 50-100 kg/ha (45 to 89 lb/acre) of potash (K_2O) for new stands.

(2) Low sulphur levels can occur in any Manitoba soil. When required apply 15 kg/ha (13 lb/acre) of sulphate sulphur. For information on the application of different forms of sulphur fertilizer, see page 25.

Source of Nitrogen

Grass For Hay — For early season grasses (first cut), ammonium nitrate is 10 to 15 per cent more efficient than urea in increasing yield. For late season grasses, urea and ammonium nitrate are equally effective in increasing yield. Urea increases the yield of the second cut (early and late season grasses) 6 - 12 per cent over that obtained with ammonium nitrate.

Grasses For Pasture — Urea is 10 - 15 per ent more effective in increasing yield than ammonium nitrate over the total grazing season.

NOTE: Crude Protein — Grasses (hay or pasture) fertilized with urea have higher crude protein levels than those fertilized with ammonium nitrate.

Time of Application

Grass for Hay or Pastures — The relative efficiency of broadcasting granular nitrogen fertilizers on established grass at different times of the year is as follows:

(1) Spring Application — April to mid May — 100%

(2) Fall Application — October — 78%

Split-rate application of nitrogen (applying equal amounts of nitrogen in the spring and immediately after each harvest except the final) is comparable to a single spring application. The split-rate technique has the added advantage of equalizing the production of forage with a relatively higher protein content throughout the growing season. The split-rate technique is particularly useful for pasture production where rotational grazing is practiced. Split applications of less than 50 kg/ha (45 lb/acre) are not recommended.

Grass for Seed Production — Timing of nitrogen fertilizer application for grass seed production is very important and varies with species. Time of application of nitrogen fertilizer for various grass species is:

TABLE 37 — GRASSES - TIME OF FERTILIZER APPLICATION

Grass	Time of Application
Meadow Fescue	October or April
Timothy	October or April
Bromegrass	Right after harvest
Russian Wild Ryegrass	Right after harvest
Wheatgrasses	Right after harvest

Fertilizing Legumes

Annual applications of fertilizer on established legume crops may be in the fall or early spring. Do not apply fertilizer to frozen soils subject to water runoff.

Additional information is contained in the Manitoba Agriculture factsheet 'Fertilizing Alfalfa Forage'.

TABLE 38 — LEGUMES - GENERAL RATE OF NUTRIENT

	N		P_2O_5			
	kg/ha	lb/acre	kg/ha	lb/acre	K_2O	S
New Stands	0	0	60-85	54-76	(1)	(2)
Established Stands	0	0	45-60	40-54	(1)	(2)

(1) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 65 to 170 kg/ha (58 to 152 lb/acre) of potash (K_2O) at the time of establishment or 45-110 kg/ha (40 to 98 lb/acre) of potash (K_2O) for established stands.

(2) 30 kg/ha (27 lb/acre) of sulfate sulphur (S) are recommended on well-drained sandy soils and grey luvisol (grey wooded) soils. For information on the application of different forms of sulphur fertilizer see page 25.

Fertilizing Mixtures

If the mixed stand contains more than 25 per cent legume, fertilize as for a pure legume stand. If there is less than 25 per cent legume in the stand, use the recommendation for pure grass stand.

Disease Control

Leaf diseases are the most commonly encountered and conspicuous disease problem with the forage grasses. If the incidence of leaf disease becomes severe, rotate the field to other crops for several years.

Ergot can be a serious problem on bromegrass and wheatgrasses. Mowing the grass at heading time will prevent the formation of ergot bodies in the developing florets. This also stops spread of the disease to nearby fields of rye, triticale, wheat, or barley. After breaking up a seed field where ergot has been a problem, avoid rye, triticale, wheat, or barley for one year.

Forage legumes are susceptible to a number of leafspot diseases. They are also affected by root and crown rots which may be associated with winter injury. Foliage diseases overwinter on infected stubble and may build up to become a severe problem. Cut before leafdrop to minimize leaf loss, reducing the amount of overwintering disease. Take severely infested fields out of production. Early spring burning prior to new growth may also reduce leaf and stem diseases. Rotate with cereals or corn for at least one year before replanting to a forage legume. (See Crop Disease Table 1 page 11).

Alfalfa and sweet clover are susceptible to verticillium wilt. To help prevent its introduction, seed can be treated with the fungicide Thiram. Avoid potatoes and sunflowers in the rotation because of common susceptibility to verticillium wilt.

For further information, refer to the Manitoba Agriculture factsheet 'Diseases and Deficiencies of Forages'.

Weed Control

For recommended herbicides and rates of application refer to Manitoba Agriculture publication 'Guide to Chemical Weed Control'.

Critical Period For Alfalfa

Autumn is the single most important management period, affecting the health, vigor, persistence and production of the stand. Alfalfa stores food reserves in its roots and such food makes the plant resistant to low winter temperatures and is used to start new growth in the spring and after each harvest. Cutting or grazing in the fall weakens plants to the level where large numbers may be winterkilled or overall production may be greatly reduced. This period is known as the 'critical fall harvest period', and is generally five weeks before the first killing frost. Leaf growth is needed during the critical fall period to synthesize food for storage in the roots and crowns. If early fall cutting is practiced, the food reserves in the roots are used to initiate new plant growth. As a consequence, plants may go into the winter low in essential food reserves. Having large food reserves in the roots and crowns does not assure that plants will survive the winter; but, plants low in these food reserves are most likely to be injured or killed. A cutting at about the average time of a killing frost is less hazardous than cutting before that time. Late fall cutting, however, removes the stubble which would catch and hold snow; the latter acts as an effective insulation blanket to protect the alfalfa during winter and early spring, thus providing additional insurance against winter kill. During a late fall cutting it is advisable to leave a .5 to one meter (two or three foot) uncut strip every swather width to act as a snow trap.

Stands that have been winter injured need conservation management to keep them in a productive condition. Winter injured plants are usually slow to start growth in the spring and are weak in appearance, yellowish in color, and have few shoots. Most winter injured plants of disease resistant cultivars can recover to near full production if the first cutting is delayed

until late bloom stage. Severely injured stands should be worked up. Cutting at immature stage may kill winter injured plants or keep them in a weakened condition. Heavy grazing and severe defoliation can result in winterkill of alfalfa.

Green Manure

Green manuring is the practice of turning green plant material into the soil to increase the organic matter. Organic matter improves soil structure, increases water holding capacity, and increases soil microbial activity thus improving soil productivity.

Legumes are the preferred crops because they will increase soil nitrogen. Sweet clover is the most common green manure crop used in Manitoba, but alfalfa or alfalfa grass can be used for the same purpose. Red or alsike clover may be sown in very moist areas. Annual or winter cereals or annual grain legumes may also be used. Non-legumes will provide cover and return organic matter but do not increase soil nitrogen.

Legumes contain about three per cent nitrogen on a dry matter basis. For example, one tonne (1.1 ton) of sweet clover would contain 30 kilograms (60 lbs) of nitrogen, about half of which may be available to the crop the year following plow-down. For maximum effect, the whole crop would be incorporated but economics or need may dictate harvesting the top growth for forage or seed production. To provide maximum nitrogen and to minimize soil moisture use, plow-down should take place at the early bloom stage.

The green manure crop may be incorporated with a single or double disc, one-way discer, or offset disc preceded or followed by a heavyduty cultivator. Sufficient trash cover should remain in the fall to catch snow and prevent soil erosion.

Generally, cereals follow the green manure crop. Although nitrogen requirements will be reduced, it is recommended that producers soil test to determine the cost benefits of additional nitrogen fertilizer. Green manure will not replace phosphorous, sulphur, or potash.

MAKING GOOD QUALITY HAY AND SILAGE

The gains in weight or milk production from feeding hay or silage are determined to a large extent by protein and fibre contents and digestibility of feed. Low quality roughage may be offset by feeding protein supplements and/or grain. Such practices generally are more costly than feeding good quality forage. Essential factors in making high quality hay or silage are as follows:

1) ***Stage of Plant Growth*** — This is the most important single factor controlling forage quality. As crops advance from early leaf to seed stages, they gradually lose feed quality (see Figure 5). Most grasses should be cut as soon as possible after heading. Legumes and grass legume mixtures should be cut when the legumes begin flowering.

2) ***Amount of Leaf*** — The feeding value of leaves is considerably higher than that of stems. Loss of leaf in handling decreases feed value. Leaf losses are likely to occur when legumes are cut and raked for hay and can be minimized by harvesting with a swather that has a conditioner attachment.

3) ***Kind of Crop*** — Legumes have higher protein and mineral content than grasses when harvested at comparable stages of growth. (See Figure 5).

4) ***Forage Harvesting Losses*** — Large losses in feeding value may result when hay is exposed to weather. Rapid curing, collection and proper storage of forage reduces these losses. The following table summarizes the types and magnitude of losses which might be expected under *good management and good harvesting conditions*, in a hay or silage system. Much higher losses are possible with all systems under fair or poor conditions. These figures are valid only if proper care and management is provided to all harvesting and storage operations.

TABLE 39 — HAY AND SILAGE - DRY MATTER LOSSES (PER CENT)

	Silage 65% Moisture Content	Silage 45% Moisture Content	Square Bales 20% Moisture Content	Round Bales 20% Moisture Content	Loose Stacks 25% Moisture Content
Respiration and Weathering Loss	4	6	10	10	9
Harvesting Loss	2	3	3	5	10
Storage Loss	10[1]	5[2]	3[3]	6[4]	10[4]
Feeding Loss	4	4	5	5	5
TOTAL	**20%**	**18%**	**21%**	**26%**	**34%**

[1]Bunker silo sealed with plastic cover
[2]Steel tower silo
[3]Hay shelter
[4]Outside storage
(Source: O. Friesen, Manitoba Department of Agriculture)

The quality of hay can only be accurately evaluated by sending forage samples to the **Provincial Feed Testing Laboratory, located in the Agricultural Services Complex, 545 University Crescent, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, Phone: 945-7694.** A regular forage test includes; dry matter percent, crude protein, acid detergent fibre, calcium, phosphorous, and estimated T.D.N. (total digestible nutrients). Additional tests on trace minerals, nitrates, urea, prussic acid, and mold analysis are available on request. It is important to note that the quality of forage may vary from year to year because of temperature and moisture differences.

Protection of hay from the weather is recommended, particularly for hay stored for more than one year. Plans for hay shelters are available through Manitoba Agriculture.

Preserving forage in the form of silage is gaining in popularity. It offers the following advantages:

- Field losses of nutrients, leaf shattering and/or weathering are reduced to a minimum. Top quality feed can be put up with little regard for the weather.
- Feed reserves can be stored cheaply for many years with little, if any, loss of nutrients.
- A wider variety of crops can be used for forage, permitting more intensive land use. All cereal grain crops and especially barley make good silage, as do all grasses and legumes. A mixture of oats and peas is often seeded for use as silage. Corn is the outstanding silage crop because of its high carbohydrate content.
- Weedy crops and crops damaged by hail or frost can be salvaged for feed.
- The harvesting system can be highly mechanized as can the feeding operation. However, it is impractical to transport silage for long distances. Fixed costs of automated equipment and upright silos are considerable and may not be feasible for smaller herds. The type of storage structure used determines silage moisture content. Table 40 indicates the recommended range of forage moisture content for different types of silos.

TABLE 40 — TYPE OF STORAGE AND RECOMMENDED FORAGE MOISTURE CONTENT

Type of Storage For Silage	% Moisture Content
Bunker, Trench, or Stack	55 - 70
Upright Silo (top unloading)	55 - 70
Upright Silo (bottom unloading)	40 - 50
Round Bale Silage (plastic enclosed)	55 - 65
Long Plastic Bag Silage	45 - 55

Damp weather is frequently the biggest obstacle to harvesting high quality hay. A few days of rain at the wrong time can reduce hay value by 25 to 50 per cent, while hot dry winds can over-dry the crop and cause high leaf losses during harvesting. Weathering and harvesting losses can be reduced by harvesting at the highest possible safe moisture content. The recommended moisture content for harvesting hay by various methods is described in Table 41.

TABLE 41 — RECOMMENDED HARVESTING MOISTURE CONTENTS

Harvesting Method	% Moisture
Forced air drying	25 - 35
Ammoniated hay (plastic enclosed)	25 - 30
Loose hay	20 - 25
Small square bales	18 - 22
Large round bales	18 - 22

Even under reasonably good weather conditions, a dry matter loss of 10 per cent can be expected before the hay crop is ready to harvest. Round balers have become very popular during the last ten years. High harvesting rates and mechanical handling of the bales have contributed to the rapid acceptance of the system. Factors affecting losses with round balers are the feed rate of the baler and the condition of the hay. The faster the hay is fed, the less turns the bale makes inside. This means less loss will occur. Wherever possible the windrow should be heavy enough to produce a full bale in two to four minutes at normal field speeds. Hay crops should be conditioned as they are cut so that the leaves will not be overdried by the time the crop is ready to bale. Conditioning also helps to provide a more positive, even feed into the baler. Overmature or badly weathered windrows will normally produce higher bailing losses than early-cut hay in good condition. Bailing during hot, dry weather should be avoided if at all possible. If the hay gets too dry, bailing early in the morning or late in the evening can help to reduce losses.

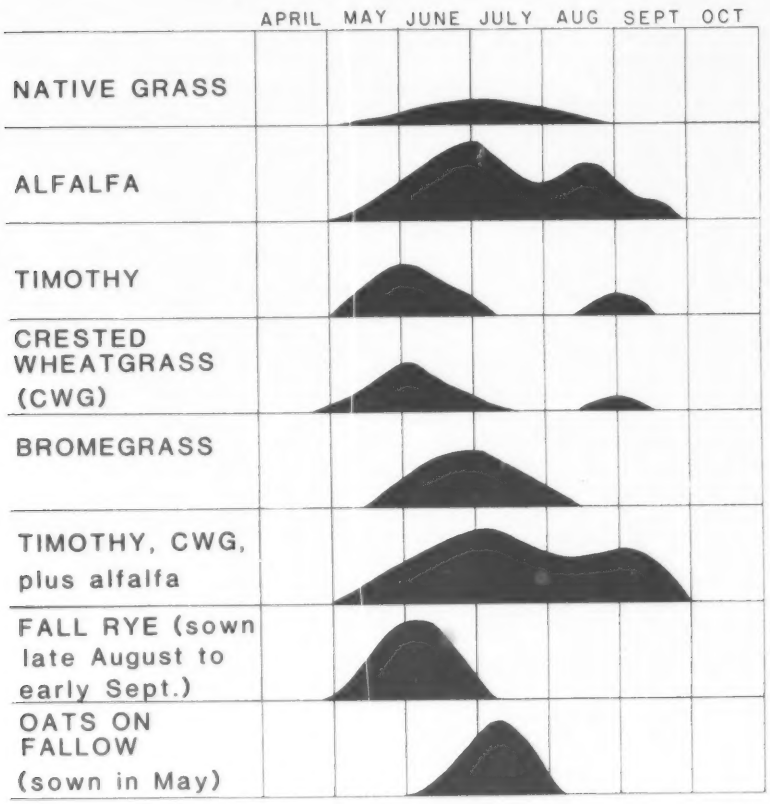
PASTURES AND PASTURE MANAGEMENT

The grazing season can range from as little as three to as much as six months with a properly managed pasture system. Productivity also has a wide variation, depending on forage type, soil, rainfall, fertility, and grazing management.

Grasses in native pastures and bush areas start growth in late spring. They give best yields when pasturing starts in mid-June and when not over grazed. Crested wheatgrass starts growth in early spring and has its greatest production in May and June. Bromegrass, intermediate wheatgrass and alfalfa grow most in June and July. Alfalfa also has another peak of production in mid to late August. Annual cereals such as oats and rye will provide good grazing starting about five weeks after seeding.

By taking advantage of variation in growth patterns and seasonable palatabilities of the forage available, producers can extend the grazing season beyond the length of time available from native grass or bush pastures, or from any single grass or grass alfalfa pasture (see figure 9).

FIGURE 10 — RELATIVE YIELD AND PERIOD OF GROWTH OF NATIVE GRASS AND SEEDED PASTURES.



Management of Native Grass Pastures

Most of the native grass pastures have been severely overgrazed, resulting in yields far short of potential. To reduce pressure on these pastures and improve their condition and yield, seeded pasture should be used in conjunction with native pasture in a complementary grazing system.

Seeded grass, or grass plus alfalfa, has the ability to produce four to eight times more than native grasses. Using the two in a complimentary system can result in greatly increased production, increased pasture season length and improved native grass condition. The extent of these increases is related directly to the proportion of seeded pasture to native grass. Native grass starts later, grows more slowly, and is sensitive to early grazing and complete defoliation.

To optimize long term production from native pastures, spring grazing must be delayed until June; livestock should be removed from the pasture when approximately 60% of the current year's growth has been grazed. This pattern of utilization can best be accommodated in a complimentary grazing system.

Other management techniques which will optimize the utilization of native pastures include: cross fencing and rotational grazing, the strategic location of watering and/or mineral facilities to promote even livestock distribution over the entire pasture, and the control of brush invasion by means of an on-going chemical or mechanical brush control program.

Management of Cultivated Pastures

Grass-legume mixtures are most commonly used for pasture and are seldom ready for grazing before May 25. Grazing too early reduces the total yield and will hasten the loss of alfalfa from the stand. Seeded pastures should be rested for three to four weeks at some time during the grazing period if the alfalfa content is to be retained permanently. This is most beneficial if a rest period starts in mid-August.

Crested wheatgrass and timothy are suitable species for spring and fall grazing. Both can be grazed beginning in mid to late May, depending on the earliness of spring. With crested wheatgrass, stocking rates should be heavy enough to remove growth by mid-June because of the rapid decrease in both quality and palatability as soon as the seed head emerges. Rotational grazing offers a number of advantages which should be considered:

- The rest between grazing periods allows alfalfa to remain more vigorous, thereby maintaining or increasing its proportion in the stand. This means that the nutritive quality of the pasture is maintained or improved and that the requirements for nitrogen fertilizer are reduced.
- Livestock graze more evenly if restricted to one portion of the pasture at a time; otherwise, they tend to overgraze or undergraze some areas, which reduces productivity.
- Where conditions permit harvesting surplus pasture as hay or silage, rotational grazing allows the manager to set aside areas for this purpose.

Seed Production

Successful forage crop seed production involves different management techniques than those used for forage production. Seeding rates are significantly lower than those utilized for hay fields or for pastures. Low seeding rates increase seed head formation and allow better pollination, resulting in higher seed yields. For seeding rates and other management

practices refer to 'Pedigreed Forage Seed Production', distributed by the Canadian Seed Growers Association and available through Manitoba Agriculture.

Pollination of red clover, sweet clover and birdsfoot trefoil is done primarily by honey bees, while pollination of alfalfa requires the use of leafcutter bees. Leafcutter bees can be maintained by the grower or can be obtained from a custom pollinator.

Weed control is a limiting factor in seed production. Few herbicides have been registered for weed control in forage seed fields, so the crops must be planted into clean fields. Fields with perennial weeds such as Canada thistle and quackgrass should be avoided. Fields with infestations of weeds with seeds which are difficult to remove from the forage seed should be avoided (eg. do not seed alfalfa into fields with heavy infestations of sweet clover or wild mustard nor timothy into fields with green foxtail or barnyard grass). Consult the 'Guide to Chemical Weed Control' for specific herbicide recommendations.

Harvesting must be timed so that shattering is avoided, particularly in crops such as timothy or birdsfoot trefoil. Chemical desiccants can be used to help speed up crop drying prior to harvest. Consult Manitoba Agriculture's 'Guide to Chemical Weed Control' for specific instructions.

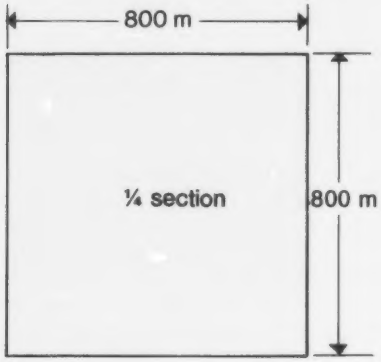
Forage Seed Marketing

Forage seed is produced for both domestic and export sales. The producer must be sure the varieties he is growing will be acceptable to satisfy those markets. Prices can fluctuate tremendously by small increases in production and demand, and growers should study the marketing options available to sell his seed. A farmer should contact the various seed purchasing firms and be aware of the various benefits and contracts offered.

The following publications are available from your Agricultural Representative or write to Manitoba Agriculture, Publications Section, 411 York Avenue, Winnipeg, Manitoba, R3C 3M1.

- Alfalfa Seed Production
- Birdsfoot Trefoil Seed Production
- Sweet Clover Seed Production
- Timothy Seed Production
- Kentucky Bluegrass Seed Production
- Legume Inoculation
- Selecting Alfalfa Varieties For Manitoba
- Guidelines For Estimating Forage Seed Production Costs — Chart (Timothy, Birdsfoot Trefoil, Sweet Clover, & Kentucky Bluegrass)
- Alfalfa Seed Cost of Production
- Guidelines for estimating Timothy Seed Production Costs.

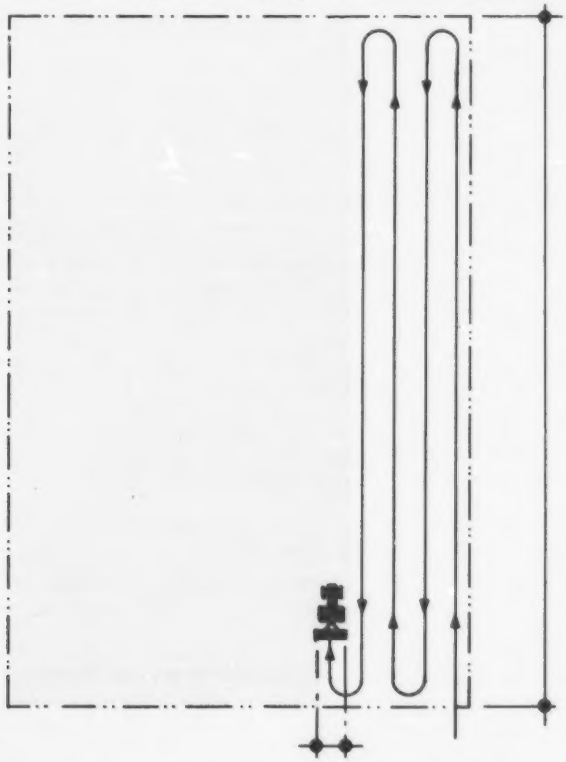
METRIC CALIBRATIONS



½ mile = 800 metres
¼ mile = 400 metres
⅛ mile = 200 metres
1 rod = 5 metres
1 foot = 0.3 metres

Procedure

1. Determine the working width of your seeder in metres (m).
2. Determine the length of your field in metres.
2. Multiply the width of the machine by the distance travelled. Divide by 10,000 to get the number of hectares covered.
4. Determine the amount of seed or fertilizer used in kilograms (kg).
5. Divide the kilograms used by the hectares covered to get kg/ha.



Example:

seed drill width — 5 metres
½ mile field — 4 passes = 4 x 800 m = 3200 m
120 kg of seed used

$$\frac{5\text{ m} \times 3200\text{ m}}{10{,}000} = 1.6\text{ ha}$$

$$\text{seeding rate is } \frac{120\text{ kg}}{1.6\text{ ha}} = 75\text{ kg/ha}$$

The procedure is the same for all seeds and fertilizers regardless of type or density.

The approximate weights of various seeds and fertilizers contained in a level full 20 litre pail are:

wheat	16-17 kg	rapeseed, mustard	13.5-14.5 kg
barley	13-14 kg	peas, beans	17-18 kg
oats	9-10 kg	sunflowers	6-6.5 kg
flax	14-15 kg	buckwheat	13 kg
rye	15-16 kg	granular fertilizer	20-21 kg

Application rates in lbs/acre can be converted to kg/ha by adding 10%. Example: 50 lbs/acre = 55 kg/ha.

METRIC CONVERSION FACTORS

SYMBOLS

kilometre	km	kilopascal	kPa
metre	m	litre	L
centimetre	cm	millilitre	mL
square metre	m^2	kilogram	kg
millimetre	mm	gram	g
hectare	ha	tonne	t
cubic metre	m^3		

Oats

1 bus/acre = 38.11 kg/ha
1 bus = 15.442 kg

Rapeseed, Mustard

1 bus/acre = 56.04 kg/ha
1 bus = 22.68 kg

Wheat, Peas, Beans, Clover

1 bus/acre = 67.25 kg/ha
1 bus = 27.22 kg

Barley, Buckwheat

1 bus/acre = 53.80 kg/ha
1 bus = 21.77 kg

Corn, Flax, Rye

1 bus/acre = 62.77 kg/ha
1 bus = 25.40 kg

1 Imp. bus = 0.0364 m^3
1 ton/acre = 2.24 t/ha

Approximate Average Bulk Densities

Wheat, peas, beans, clover	770 kg/m^3
Rye	730 kg/m^3
Corn	700 kg/m^3
Flax	650 kg/m^3
Rapeseed, mustard	640 kg/m^3
Barley	620 kg/m^3
Buckwheat	610 kg/m^3
Oats	470 kg/m^3
Sunflower Seed	290 kg/m^3

1 Imp. fl. oz. = 28.41 mL
1 Imp. fl. oz./acre = 70.21 mL/ha
1 oz = 28.35 g
1 lb/acre = 1.121 kg/ha
1 oz/acre = 70.06 g/ha
1 lb/in^2(psi) = 6.895 kPa
1 HP = 0.7457 kW

1 Imp. gal = 4.546 L
1 Imp. gal/acre = 11.23 L/ha
1 U.S. gal = 3.785 L
1 lb = 0.4536 kg
1 acre = 0.4047 ha
1 ft = 0.3048 m
1 in = 2.54 cm

10 mm = 1 cm
100 cm = 1 m
1000 m = 1 km
10,000 m^2 = 1 ha

1000 mL = 1L
1000 L = 1 m^3
1000 g = 1 kg
1000 kg = 1 t

NOTES

NOTES

TABLE 30 — GRASS ADAPTATION GUIDE

CROP	ADAPTATION									
	Average Number of Seeds Per Kilogram *(Pound)*	**Plant Type**	**Plant Height[1] cm *(in)***	**Longevity Under Average Manitoba Conditions**	**Winter Hardiness**	**Flooding Tolerance[2]**	**Drought Tolerance**	**Salinity Tolerance**	**Preferred Climate and Soil Type**	**Period Of Major Production**
Kentucky Bluegrass	4,840,000 *(2,200,000)*	Creeping, sod-forming	30-75 *(12-30)* Basal leaves	Long	Excellent	Medium	Good when plant is dormant	Poor	Cool, humid. 500-1250 mm *(20-50 in)* precipitation. Will grow on almost any well-drained soil.	Spring Fall
Smooth Bromegrass	297,000 *(135,000)*	Creeping, sod-forming	60-120 *(24-48)*	Long	Excellent	Medium	Good when plant is dormant	Fair	Moist, well drained soils.	Spring
Creeping Red Fescue	1,353,000 *(615,000)*	Creeping	60-120 *(24-48)* Basal leaves	Long	Excellent	Medium	Fair to good	Poor	Cool, humid areas. Will grow in wide range of soil types.	Spring Fall
Meadow Fescue	506,000 *(230,000)*	Bunch	35-75 *(14-30)* Basal leaves	Medium	Good	High	Good	Fair	Soils with ample moisture and good drainage.	Spring through Fall
Orchardgrass	1,430,000 *(650,000)*	Bunch	60-120 *(24-48)*	Short	Fair (unless protected)	Low	Fair	Poor	Warm, moist areas with over 500 mm *(20 in.)* precipitation. Good drainage.	Spring through Fall
Reed Canarygrass	1,166,000 *(530,000)*	Creeping (short rhizomes)	60-240 *(24-96)*	Long	Good except where exposed	High	Fair	Fair	Moist, cool climate; poorly drained areas subject to temporary flooding.	Spring through Summer

FOOTNOTES: 1. Plant Height — Height to the top of the seedhead. Not a good measurement for evaluating bunch grasses.
2. Flood Tolerance — These readings were taken in spring flooding situations when the grasses were dormant.
3. Forage production figures represent yields at St. Claude only, and may not be representative for all areas of the Province.
4. Seed production figures from test site at Arborg only.
5. Crude Protein — These figures represent figures for two harvests at St. Claude. Most forages were harvested in the early heading stage.

(Table 30 Continued on next page)

	PRODUCTION					
mate and	**Period Of Major Production**	**Crop Production Forage[3] kg/ha *(lbs/acre)* Seed[4] kg/ha *(lbs/acre)***	**Crude Protein[5]**	**Use in Manitoba**	**Positive Features**	**Negative Features**
00-1250 mm ipitation. most any il.	Spring Fall	Forage 1300-3300 *(1170-2970)* Seed 100-500 *(90-450)*	14-15% Mean of two harvests.	Turf Seed Pasture	Tolerates close and frequent defoliation. Tolerates wet conditions for short periods of time. Can be regenerated from rhizomes. Useful in erosion control.	Slow to establish. High moisture requirements; dormant in hot, dry weather.
ined	Spring	Forage 5600-8800 *(5040-7920)* Seed 600-800 *(540-720)*	15-16%	Hay Pasture Seed	Winter-hardy; drought and heat tolerant. Grows on diversity of soil types. Palatable even at mature growth stages.	Seed light and difficult to sow (bridging). Slow to establish. Becomes sod-bound in absence of nitrogen. Weakened by heavy grazing. Susceptible to winter crown and root rot.
eas. Will nge of	Spring Fall	Forage 4000-4500 *(3600-4050)* Seed 100-450 *(90-405)*	14-16%	Turf Pasture Seed	Vigorous seedling. Tolerates low fertility and close grazing. Tolerates areas too dry for timothy. Starts growth fairly early in spring. Grows vigorously late summer to freeze-up.	Palatability fair. Vulnerable to crown and root rots and to snow mold.
e moisture age.	Spring through Fall	Forage 1500-7800 *(1350-7020)* Seed 100-900 *(90-810)*	13.5-17.0%	Seed Pasture	Establishes rapidly on wide range of soils. Productive throughout entire growing season.	Does not persist under continuous heavy grazing. Susceptible to leaf rusts. Less palatable than most grasses.
eas with 0 in.) od	Spring through Fall	Forage 3600-5000 *(3240-4500)* Seed 125-300 *(113-270)*	16-18%	Pasture Hay	Rapid establishment. Rapid regrowth following harvest. Shade tolerant. Compatible with alfalfa.	Only moderately winter hardy. Requires high nitrogen inputs for high production. Coarse and unpalatable at maturity.
ate; areas orary	Spring through Summer	Forage 4000-8300 *(3600-7470)*	18.5-19.2%	Hay Pasture Seed	Grows well in wet areas and can withstand considerable flooding. Remains productive throughout season. Excellent grass for waterways and areas subject to water erosion.	Seed difficult to sow. Slow to establish a sod. Palatability declines rapidly with advance in maturity. Alkaloids in forage associated with decrease in animal performance.

ge.

TABLE 30 — GRASS ADAPTATION GUIDE — Cont'd

CROP	ADAPTATION									
	Average Number of Seeds Per Kilogram *(Pound)*	**Plant Type**	**Plant Height[1] cm *(in)***	**Longevity Under Average Manitoba Conditions**	**Winter Hardiness**	**Flooding Tolerance[2]**	**Drought Tolerance**	**Salinity Tolerance**	**Preferred Climate and Soil Type**	**Period O Major Product**
Timothy	2,700,000 *(1,227,000)*	Bunch	50-100 *(20-40)*	Medium	Good	High	Poor	Poor	Cool, moist areas with good drainage.	Spring through Summer
Crested Wheatgrass	Diploid (Fairway) 704,000 *(320,000)* Tetraploid (Nordan) 418,000 *(190,000)*	Bunch	50-90 *(20-36)*	Long	Excellent	Low	Good (Fairway type goes dormant faster than Nordan type.	Fair	Light soils and areas deficient in moisture. Can be grown on most soils if they do not have high water table.	Spring and Fall
Slender Wheatgrass	352,000 *(160,000)*	Bunch	60-120 *(24-48)*	Short (4-5 years)	Excellent	High	Good	Good	Adapted to wide range of soils but prefers sandy loams.	Spring and Early Summer
Intermediate Wheatgrass	194,000 *(88,000)*	Creeping (short rhizomes)	90-150 *(36-60)*	Short (about 6 years)	Excellent	Medium	Good	Poor	Well drained fertile soils with ample moisture.	Spring Summer and Fall
Tall Wheatgrass	174,000 *(79,000)*	Bunch (short root-stocks)	90-180 *(36-72)*	Long	Excellent	High	Poor	Good	Adapted to saline and imperfectly drained alkali soils. Prefers soils with high water table. Survives flooding for 2 months in spring. Needs 375 mm *(15 in.)* minimum precipitation.	
Russian Wild Ryegrass	385,000 *(175,000)*	Bunch basal leaves 15-45 cm *(6-18 in.)*	50-90 *(20-36)*	Long	Excellent	Low	Good	Fair	Can be grown on a wide range of soil types but is most productive on *fertile loams.*	Spring through Fall

FOOTNOTES: 1. Plant Height — Height to the top of the seedhead. Not a good measurement for evaluating bunch grasses.
2. Flood Tolerance — These readings were taken in spring flooding situations when the grasses were dormant.
3. Forage production figures represent yields at St. Claude only, and may not be representative for all areas of the Province.
4. Seed production figures from test site at Arborg only.
5. Crude Protein — These figures represent figures for two harvests at St. Claude. Most forages were harvested in the early heading stage.

	PRODUCTION					
	Period Of Major Production	**Crop Production Forage[3] kg/ha *(lbs/acre)* Seed[4] kg/ha *(lbs/acre)***	**Crude Protein[5]**	**Use in Manitoba**	**Positive Features**	**Negative Features**
	Spring through Summer	Forage 4500-6125 *(4150-5513)* Seed 100-900 *(90-810)*	12.5-15%	Seed Hay Pasture	Seed plentiful and low priced. Stand establishment is rapid. Offers little competition to the legume in mixtures.	Susceptible to heat and low moisture conditions. Low palatability and feed value at maturity. Weakened by heavy grazing or frequent cutting.
	Spring and Fall	Forage 6000-10,000 *(5400-9000)*	Diploid 13.5-15% Tetraploid 14-16.5%	Pasture Hay Seed	Easily established on wide range of soils. Withstands close grazing and trampling. Palatable in early spring.	Does not tolerate cool, wet soils, (especially tetraploid). Hay quality deteriorates rapidly after heading. Slow regrowth after hay harvest.
	Spring and Early Summer	Forage 3800-5500 *(3420-4950)* Seed 400-600 *(360-540)*	14-16%	Hay Seed	Good seedling vigor; easily established. Shade tolerant. Forage cures well on stem. High salinity tolerance.	Less competitive and persistent than other wheatgrasses. Not resistant to close or heavy grazing.
	Spring Summer and Fall	Forage 5000-9000 *(4500-8100)* Seed 500-850 *(450-765)*	16-19%	Hay Pasture Seed	Easily seeded. Begins growth in early spring. In drier areas outyields crested wheatgrass and brome. Good hay grass in associations with alfalfa.	Less drought tolerant and winter-hardy than crested wheatgrass. Does not tolerate salinity. Does not persist in areas with poor drainage.
		Forage 5200-6200 *(4680-5580)* Seed 900-1700 *(810-1530)*	14.5-15.0%	Hay Seed	Very tolerant of saline soils. In **early** heading stage has high protein and TDN ratings.	Slow to establish — poor germinability, poor vigor and poor competitive ability. Not as palatable as other wheatgrasses.
	Spring through Fall	Forage 4500-6400 *(4050-5760)* *Seed* 140-500 (126-450)	21-24%	Pasture Seed	Early, excellent dryland crop. Roots draw on moisture up to 1.5 m *(approx. 5')*. Very tolerant of grazing; regrows quickly. Palatable and nutritious in mature stage. Good salinity tolerance.	Poor seedling vigor, therefore poor competitor in establishment year.

TABLE 31 — LEGUME ADAPTATION GUIDE

CROP	ADAPTATION							
	Seeds Per Kilogram (Pound)	**Characteristics of the Crop**	**Longevity Under Average Manitoba Conditions**	**Flood Tolerance[1]**	**Salinity Tolerance**	**Drought Tolerance**	**pH Range For Optimum Growth**	**Adaptation**
Alfalfa	484,000 *(220,000)*	This crop has a tap root, good crown development and erect stems. Forage production high throughout season.	Long	10 days	Fair	Good	6.5-8.0	Well adapted to a wide range of climatic and soil conditions where drainage good.
Sweet Clover	572,000 *(260,000)*	First season growth consists of a central, much branched stem. Crown buds produce rapidly growing, tall, coarse stems in second year. Strong tap roots.	2 years	14 days	Fair	Good	6.5-8.0	Especially productive on fi tile, well-drained clay & cl loam soils. May also be grown on soils which are n flooded or acid.
Birdsfoot Trefoil	713,000-1,200,000 *(324,090-545,000)*	Strong deep tap root system with many side branches. Can regenerate crowns from root portions. Fine-stemmed but not as erect or tall as alfalfa.	Long	14 days	Fair	Fair	5.5-7.5	Prefers moist areas; tolera of water-logged, low fertilit and organic soils, & some saline soils.
Red Clover	550,000 *(250,000)*	Short tap roots with side branches. Good stands persist for one to three years depending on variety, soil, moisture and temperature.	1-3 years	7-14 days	Poor	Poor	6.0-7.5	Best suited to humid areas with moderate temperatur
Alsike	1,540,000 *(700,000)*	A profusely tillering prostrate plant with indeterminate growth habit.	2-4 years	14 days	Poor	Poor	5.5-7.5	Prefers low-lying moist areas.

FOOTNOTES: *1.* These readings are for spring flooding conditions when the legume is dormant. The tolerance ratings will be much lower when the crop is actively growing and
2. These figures were obtained from one site when the crops were at the first flower stage.
3. Production figures were taken from the St. Claude (Forage) and Arborg (Seed) sites. The figures represent a range in production in a common test period.

	PRODUCTION					
Adaptation	**Period Of Major Production**	**Crude Protein[2] %**	**Production[3] kg/ha *(lbs/acre)***	**Primary Uses**	**Positive Features**	**Negative Features**
Well adapted to a wide range of climatic and soil conditions where drainage is good.	Spring to Fall	19%	Forage 6000-14000 *(5400-12600)* Seed 200-700 *(180-630)*	Hay, Pasture & Seed	Easily established on most soils with good drainage. High yields of good quality forage. Rapid regrowth following grazing or clipping.	Bloat hazard. Requires good drainage. Poor persistence when grazed or clipped frequently.
Especially productive on fertile, well-drained clay & clay-loam soils. May also be grown on soils which are not flooded or acid.	Spring of Second Year	15%	Forage 3000-7000 *(2700-6300)* Seed 200-1100 *(180-990)*	Green Manure, Hay-silage, Seed & Pasture	Grows under a wide range of soil and climatic conditions. Excellent for soil and drainage improvement. Low coumarin varieties available.	Seedling stands thinned or destroyed by sweet clover weevils. Low palatability unless harvested early. Coumarin content of some varieties can cause feeding problems.
Prefers moist areas; tolerant of water-logged, low fertility and organic soils, & some saline soils.	Spring to Fall	19%	Forage 5000-6000 *(4500-5400)* Seed 400-900 *(360-810)*	Seed & Pasture	Long-lived. Will grow on wide range of soil conditions. Reseeds itself when conditions are favorable. Feed value similar to alfalfa. No bloat hazard.	Poor seedling vigor; poor competitor in weedy stands. Slow to come into full production. Lodges easily. Slow recovery after grazing or clipping.
Best suited to humid areas with moderate temperatures	Spring	17%	Forage 4500-5600 *(4000-5000)* Seed 100-400 *(90-360)*	Seed & Hay	Easy to establish. Tolerates soils wetter and more acid than does alfalfa.	Bloat hazard. Short life span due to a number of crown and root diseases.
Prefers low-lying moist areas.	Spring	17%	Forage 5000-5500 *(4500-4950)* Seed 100-300 *(90-270)*	Hay & Seed	Tolerant to poor drainage and acid soils.	Bloat hazard. Short life span. Low aftermath yield.

crop is actively growing and soil and air temperatures are high. Most legumes would be severely damaged by a few days of summer flooding.

in a common test period.